

FEBRUARY 1956



VOL. 48 • NO. 2

Journal

AMERICAN
WATER WORKS
ASSOCIATION

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Filter Plant Design

Pipe Coating Tests

Electrical Inspection of Coatings

Design of Cement-lined Steel Pipe

Electrical Reliability

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Specifications for Butterfly Valves

Hartung

Burnett, Lewis

Davidson

Cole

Potthoff, Hadley

Kesler

Ningard, Willson

Mathews

Berry, Stockwell

Bellack, Maier

AWWA C504, C505

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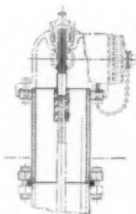
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Journal

AMERICAN WATER WORKS ASSOCIATION

521 FIFTH AVE., NEW YORK 17, N.Y.

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February 1956

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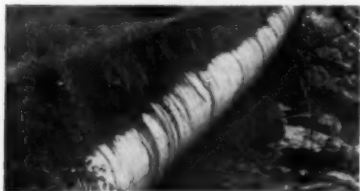
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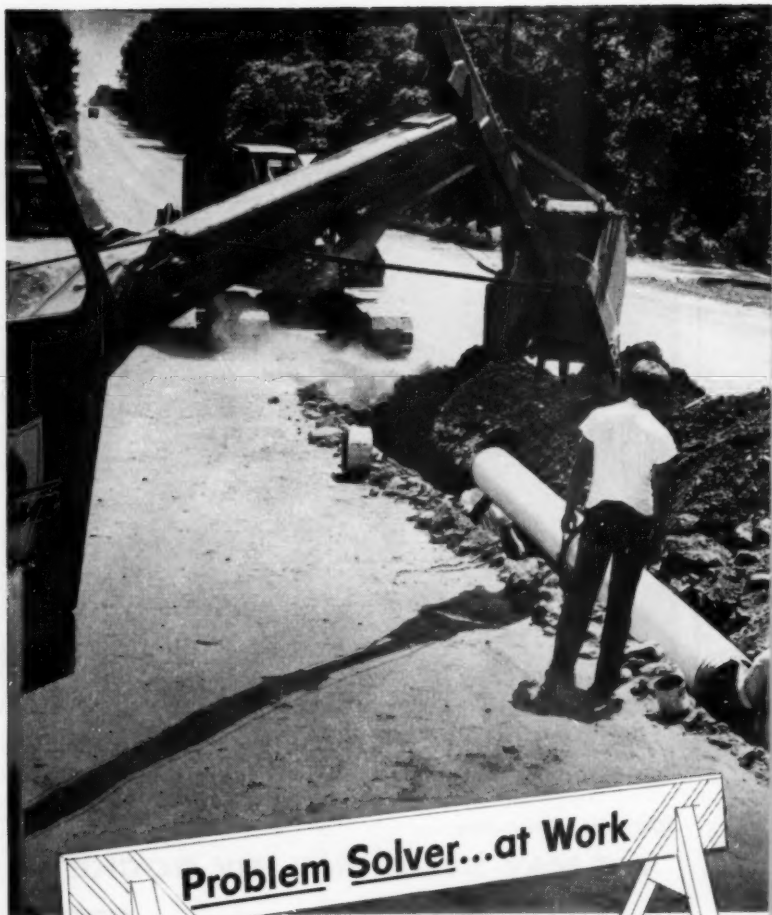
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with the **RING-TITE Coupling**



AWWA DIAMOND JUBILEE CONFERENCE**St. Louis, Mo.****May 6-11, 1956**

All reservations will be cleared through the AWWA office. The nine official hotels have agreed to accept no reservations for the 1956 Conference except as they are requested on the standard form, through the AWWA.

*Coming Meetings***AWWA SECTIONS**

Mar. 18-21—Southeastern Section, at Bon Air Hotel, Augusta, Ga. Secretary, N. M. deJarnette, Georgia Dept. of Public Health, 245 State Office Bldg., Atlanta 3.

Mar. 21-23—Illinois Section, at LaSalle Hotel, Chicago. Secretary, D. W. Johnson, Cast Iron Pipe Research Assn., 122 S. Michigan Ave., Chicago 3.

Apr. 3-5—Pennsylvania Section, at Bellevue-Stratford Hotel, Philadelphia. Secretary, L. S. Morgan, State Dept. of Health, Greensburg.

Apr. 4-6—Kansas Section, at Jayhawk Hotel, Topeka. Secretary, H. W. Badley, Neptune Meter Co., 119 W. Cloud St., Salina.

Apr. 5-7—Arizona section, at Buena Vista Hotel, Safford. Secretary, Quentin M. Mees, Arizona Sewage & Water

Works Assn., 721 N. Olsen Ave., Tucson.

Apr. 6-7—Montana Section, at Murray Hotel, Livingston. Secretary, A. W. Clarkson, State Board of Health, Helena.

Apr. 11-13—Nebraska Section, at Cornhusker Hotel, Lincoln. Secretary, J. E. Olsson, Fulton & Cramer, 922 Trust Bldg., Lincoln.

Apr. 18-20—New York Section, at Hotel Utica, Utica. Secretary, Kimball Blanchard, Rensselaer Valve Co., 11 W. 42nd St., New York 36.

Apr. 23-25—Canadian Section, at Hotel London, London, Ont. Secretary, A. E. Berry, 72 Grenville St., Toronto, Ont.

Apr. 26-28—Pacific Northwest Section, at Empress Hotel, Victoria, B.C. Secretary, F. D. Jones, Room 305, City Hall, Spokane, Wash.

(Continued on page 68 P&R)

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Savings because fewer joints are needed — and fewer supports. Savings from simpler hauling, easier handling in the field — from faster assembly and installation — and lower labor costs.

And of course greater lengths add up to less chance of leakage — which rings up bigger savings in your budget department.

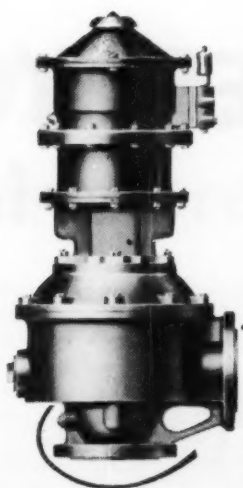
To make a long story short — you're smart to specify steel pipe.

"WHEREVER WATER FLOWS — STEEL PIPES IT BEST"

**STEEL PLATE FABRICATORS
ASSOCIATION**

79 W. MONROE ST., CHICAGO 3, ILL.





New Simplex Type CCAV Valve.
Combination controlled-closing
and vacuum-breaking valve.

**ONE 4-INCH
CONNECTION
to your main
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PREVENTS { **surge rupture
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Why take chances? No matter what the safety factor, surge and hammer can play some dirty tricks . . . rupture lines, blow out packing, fracture valves. And if the line breaks or is drained rapidly, it can collapse from vacuum.

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To you it's waste that can be eliminated only by an educated and alert public, willing to cooperate in your efforts at conservation.

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Today, water officials can rely on even better cast iron pipe. Modernized cast iron, centrifugally cast to be even tougher, stronger, more uniform. And where needed and specified it is cement-lined to assure sustained carrying capacity throughout its long service.

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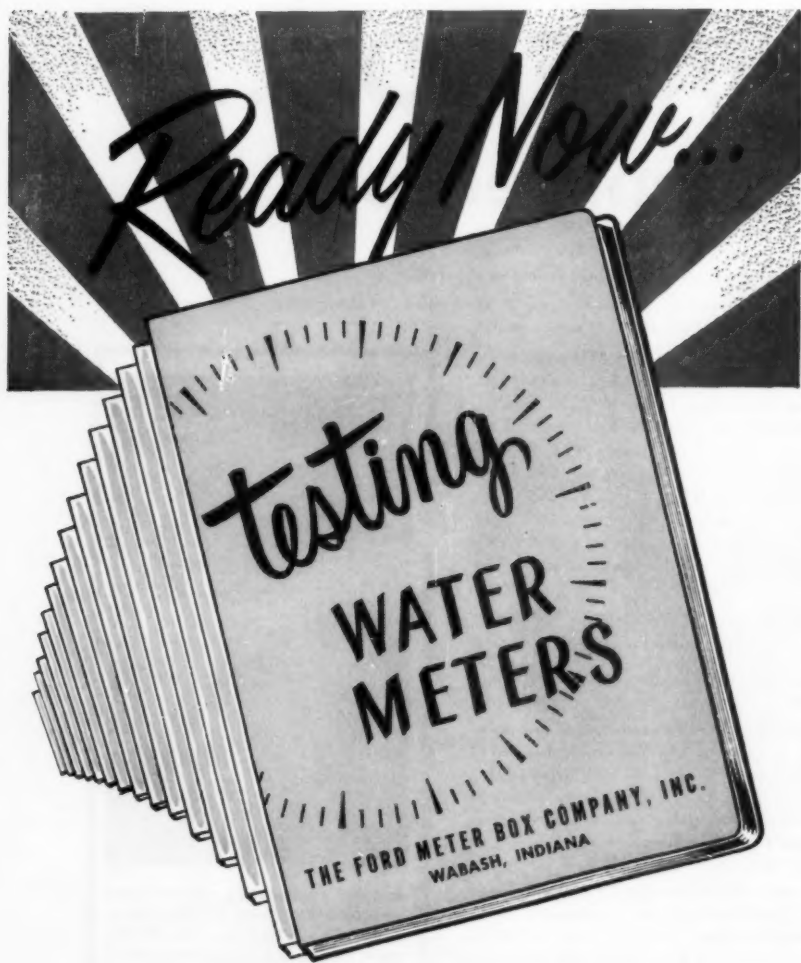
Laid 120 years ago this cast iron water main continues to serve the taxpayers of Lancaster, Pa. Photo shows section of a line about 1½ miles long, laid in 1836, and still a part of the Lancaster water distribution system.

CAST IRON

The Q-Check stencilled on pipe is the Registered Service Mark of the Cast Iron Pipe Research Association.

pipe

FOR MODERN WATER WORKS



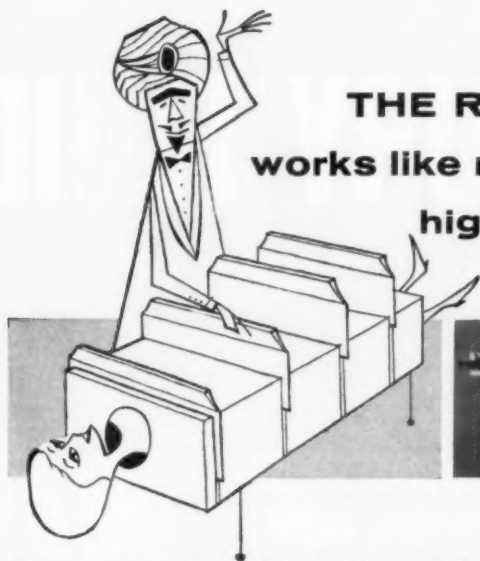
This 40 page book gives useful information, charts, data and instructions on water meter testing. Should be in every meter shop. Available on request without charge or obligation.

SEND FOR YOUR COPY

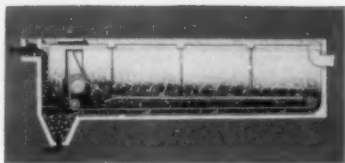
THE FORD METER BOX COMPANY, INC.
WABASH, INDIANA

FOR BETTER WATER SERVICES





THE REX VERTI-FLO works like magic in cutting high settling costs



The amazing ability of Rex Verti-Flo Clarifiers to reduce costs... assure clearer effluent... increase over-all plant efficiency... is almost magical. Actually the Verti-Flo design *divides* a horizontal-flow settling tank into a series of smaller, vertical-flow cells.

These Verti-Flo users are getting increased efficiency... lower costs... clearer effluent

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Valencia, Venezuela	Alderson, W. Va.

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Whether you specify equipment or operate a plant, you should know the facts about Rex Verti-Flo. Why not have the advantages of Rex® Verti-Flo in your plant? For complete details, mail the coupon today for your copy of Bulletin 52-77. You'll be happy you did.

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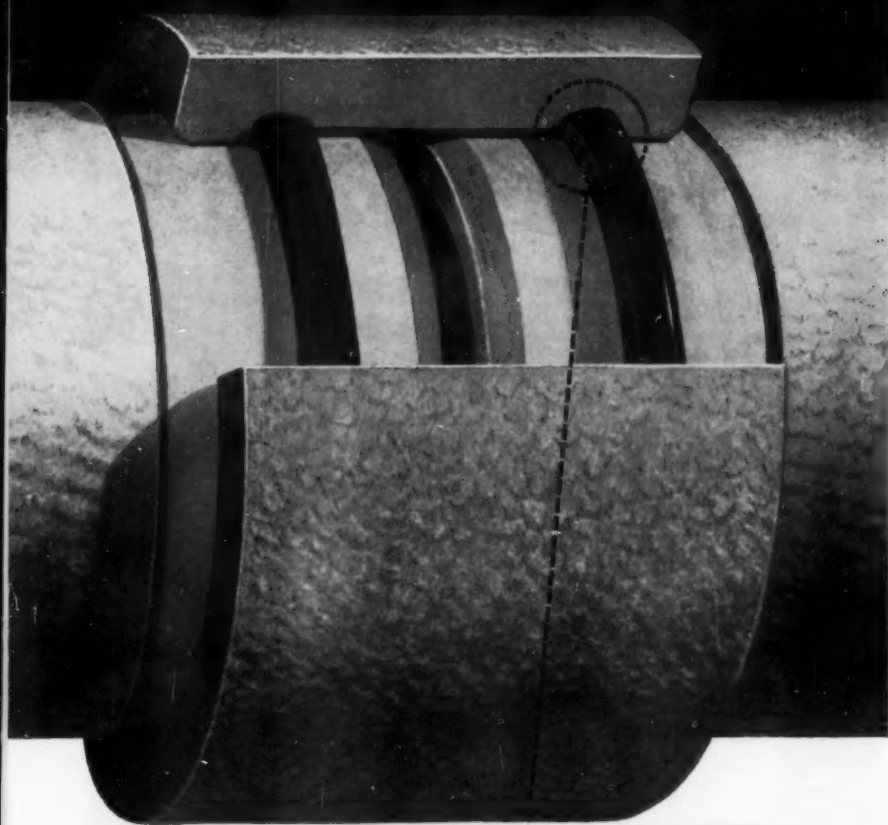
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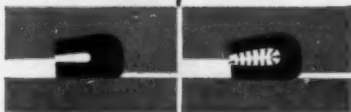
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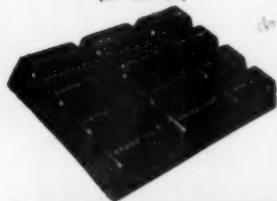
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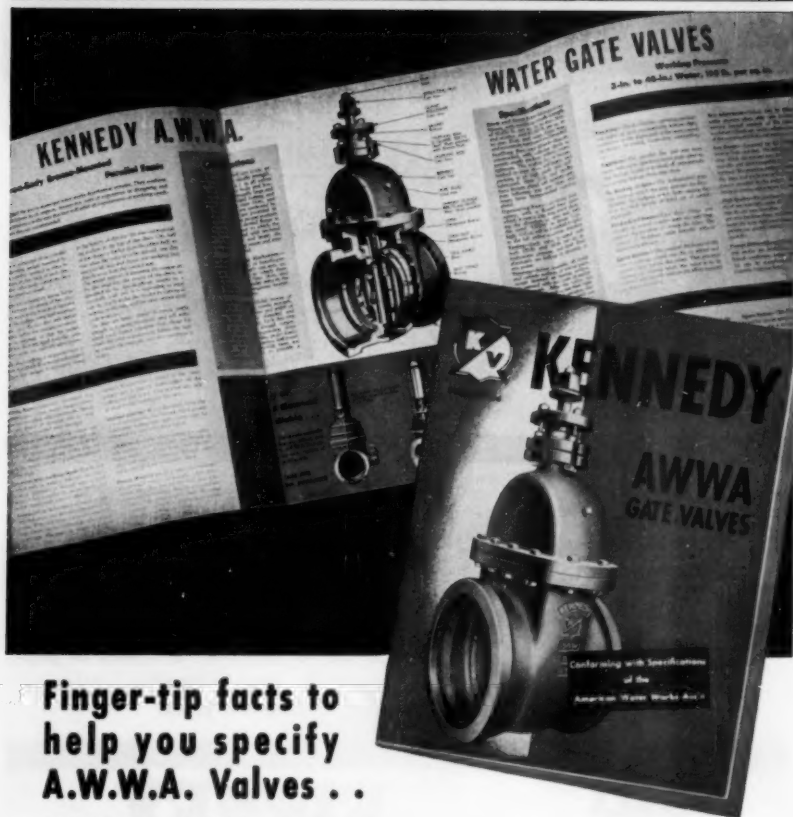


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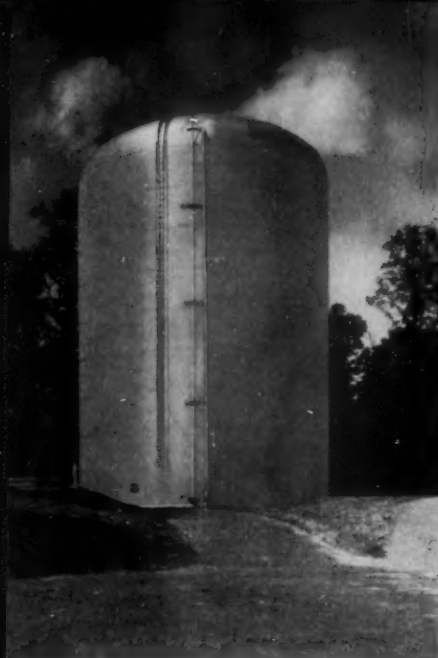
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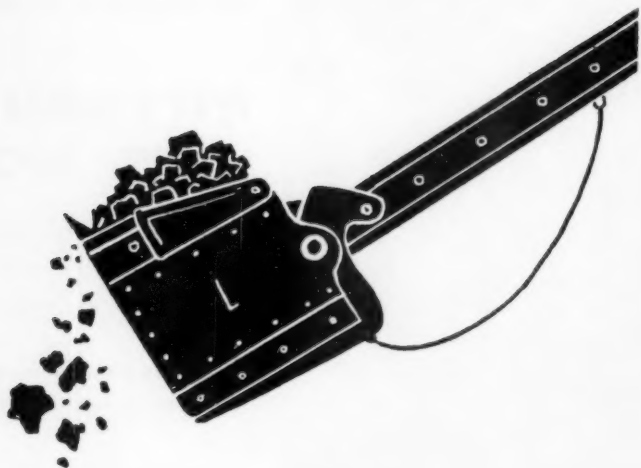
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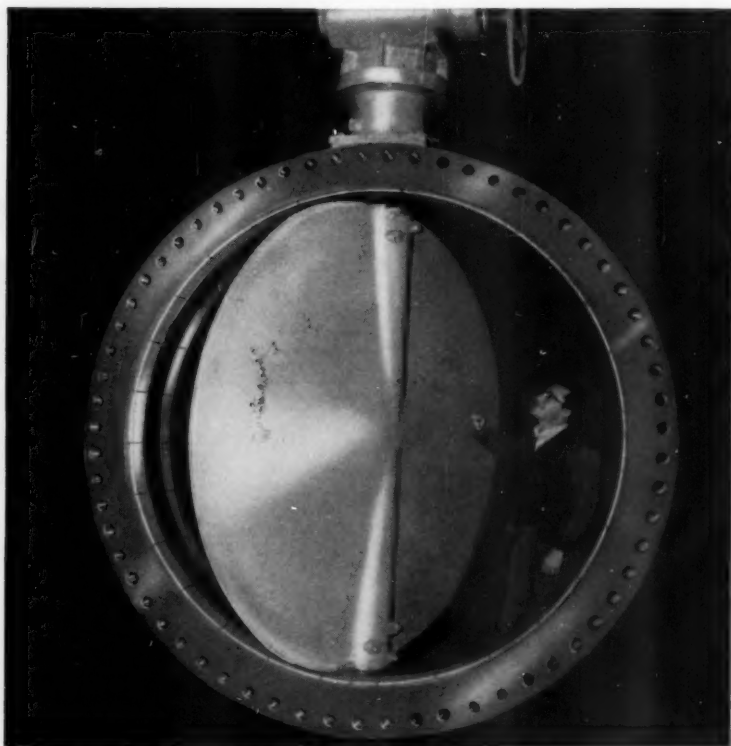
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Q. How about cost—isn't steel pipe high?

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Q. Will steel pipe corrode and tuberculate, and require cleaning?

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Q. If steel pipe "gives," won't it collapse under the weight of cover?

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other hand, takes the entire load. It can't transmit the load to the earth, or conform when fill is washed away, and it frequently breaks. Steel pipe is far more resistant to damage due to heavy cover, vibration, impact, explosions, washouts, etc.

Q. Will steel pipe leak? Are the joints tight?

A. You definitely can get the tightest joints with steel pipe. When you use couplings or welds, your line can be 100 pct leakproof.

Q. Can steel pipe handle high working pressures?

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Q. Who uses steel pipe?

A. Hundreds of water systems in this country and throughout the world are using steel pipe today and have used it for many years.

Q. Where can I get further information?

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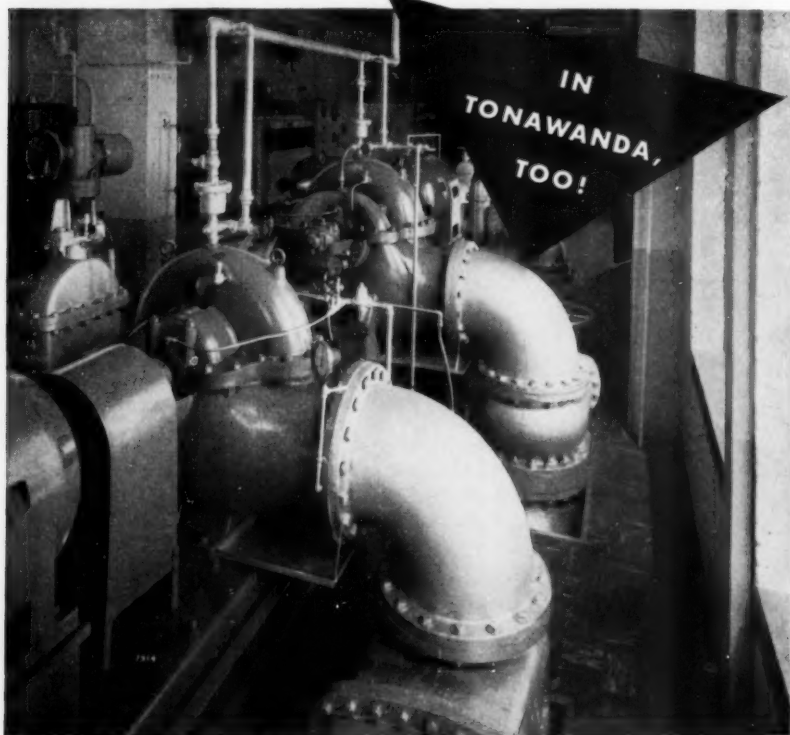
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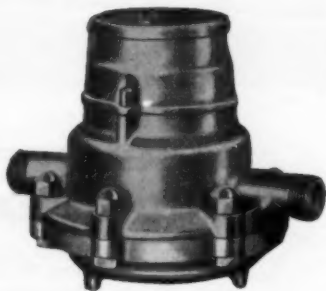
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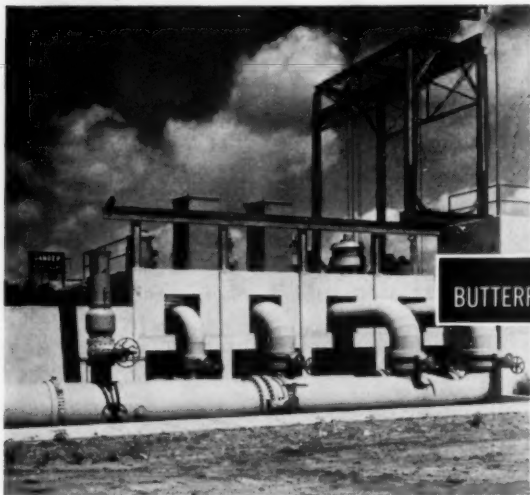
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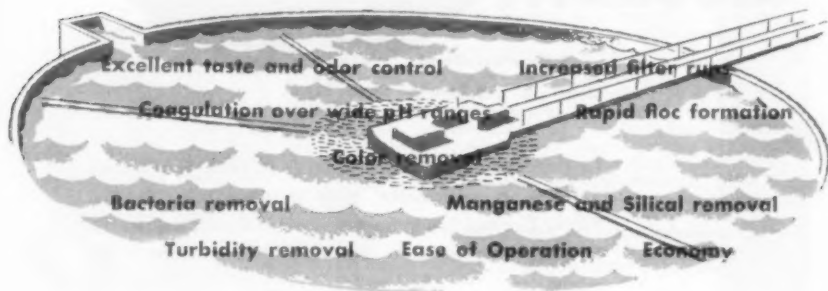
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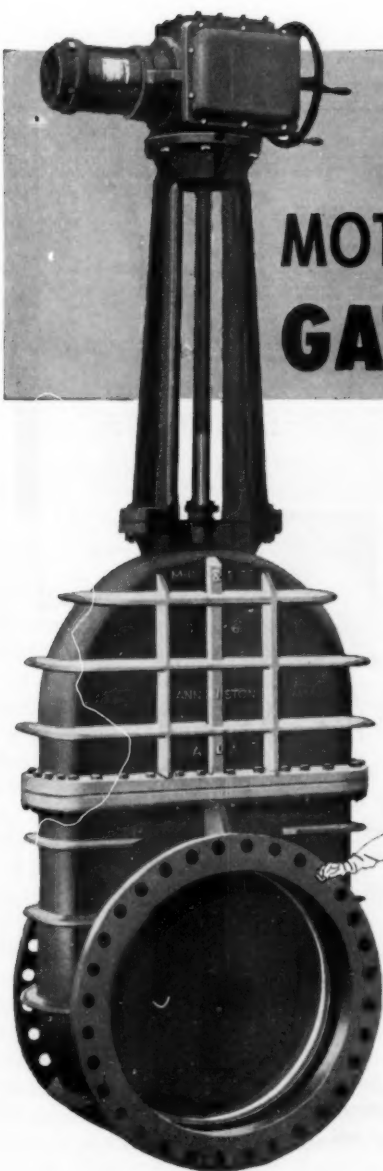
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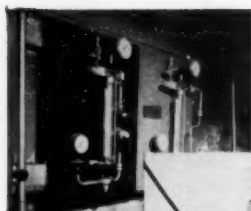
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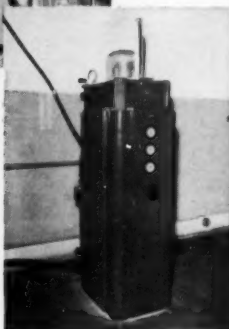
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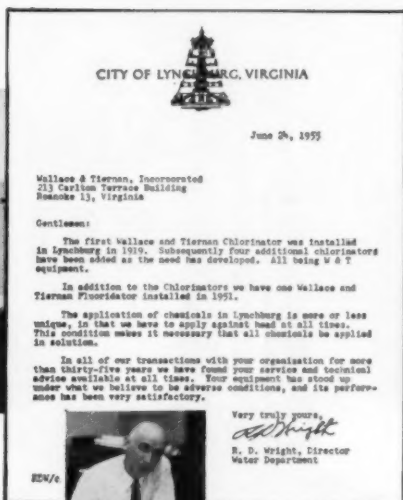
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AMERICAN WATER WORKS ASSOCIATION

VOL. 48 • FEBRUARY 1956 • NO. 2

Unique Features in Filter Plant Design

H. O. Hartung

A paper presented on Jun. 15, 1955, at the Annual Conference, Chicago, Ill., by H. O. Hartung, Production Supt., St. Louis County Water Co., University City, St. Louis, Mo.

THE most expensive parts of a water treatment plant are usually the filters, filter auxiliaries, and building. Yet, when compared to the prefiltration, chlorination, and other facilities of the properly designed water treatment plant, the filters often add the least to water quality. Their cost seems to be out of proportion to their contribution. This is especially true in surface water plants where the filters merely add a slight turbidity reduction to the water and strain out the larger biological life after major turbidity reduction has already taken place in coagulation and settling basins. It is also true in some properly designed softening plants where the filters only remove a minor amount of softening floc. Quite often the major purification work of a water plant is accomplished in the prefiltration facilities. Nevertheless, filters are important to water quality and are indispensable on most water treatment flow sheets.

Two important questions are concerned here. One is investigation of

the design features of filters and filter construction to lower their cost without affecting their present-day utilitarian value. Of less importance at present, although valuable, is the study of design for improving the amount of water purification which a filter can do, so that filter value becomes more commensurate with filter cost.

Conventional Design

Conventional filter plant design was developed years ago, during a period when construction costs were appreciably less than they are today. Early filter construction cost had an entirely different influence on total cost (fixed charges plus operating cost) of water treatment than do today's filter plant construction costs. Since that time, filter design, with a few exceptions, has not materially changed to keep pace with the changing construction market. Designers seem to have merely continued to copy previous designs. As a result, so-called conventional filter plant design, in today's con-

struction market, has fast become very expensive.

Because many water utilities since World War II have been, and are now, confronted with the necessity of increasing filter plant capacity, and at the same time are faced with consumer resistance to realistic water rate increases, a number of engineers have

a function can be accomplished differently at less cost. As a result, there have been some innovations and changes in conventional filter plant design.

There is another consideration which is concerned in this re-examination of filter design. Prefiltration water treatment has been dependably and mark-

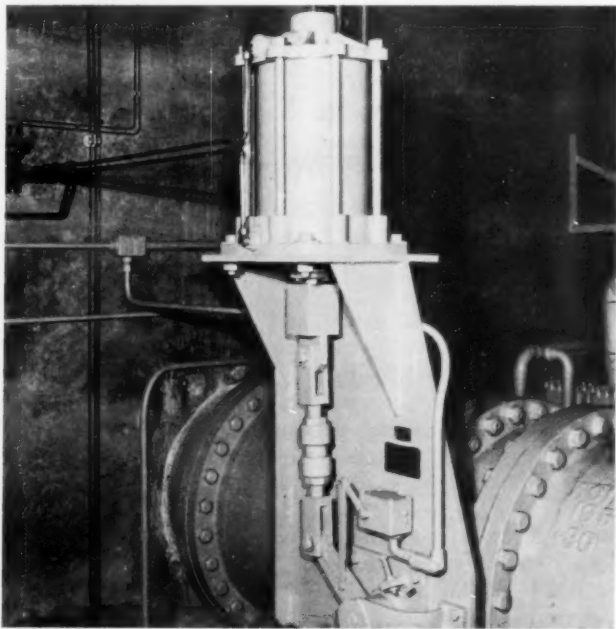


Fig. 1. Butterfly Valve Used as Filter Valve

In comparison with gate valves, the butterfly valves have tight seating characteristics, smaller hydraulic cylinders, and lower initial cost. For smaller-size filter valves, the hydraulic square-bottom gate valve is less expensive than the butterfly valve.

re-examined conventional filter design practice in the light of experience, hoping to cut filter plant construction costs. With regard to filters and component parts, these engineers question the necessity of such items or the possibility for simplification, and consider whether

edly improved since conventional filter design evolved. The water applied to filters is of better quality and has better filterability characteristics, resulting from better and longer mixing, improved chemical treatment, more adequate chemical-feeding equipment, and

advanced basin design. Because of this improved prefiltration water treatment, the amount of work which filters must do is also different. Some design engineers, therefore, are suggesting that possibly filters can be equipped and constructed more simply, the purification work load on the filter having materially lessened.

a low-cost functional filtration plant is to decide how large the filter unit can be. The most economical size can then be determined.

The dimensional size of a filter unit is directly related to the selected design unit filtration rate. For that reason, more and more filter plants are being built with a designed 3-4-gpm per

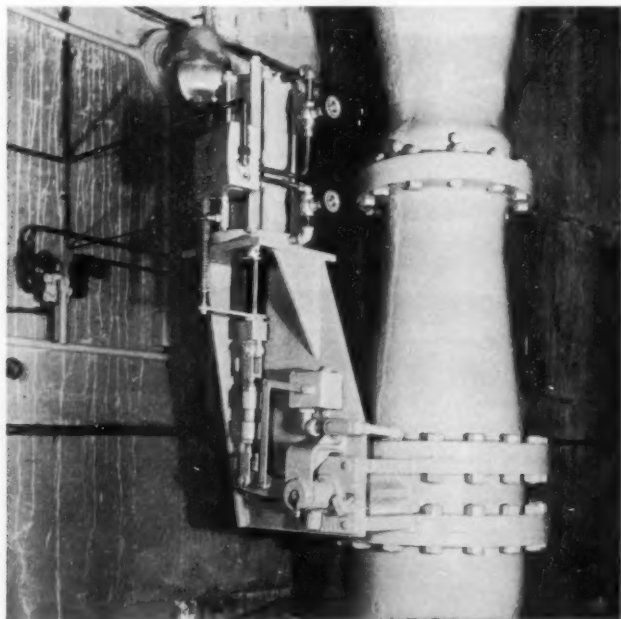


Fig. 2. Filter Effluent and Rate-of-Flow Control Valve

The filter effluent valve is used for both rate-of-flow control valve and a tight shut-off valve. The valve shown here is equipped with a pneumatic valve positioner. For every air pressure received by the positioner between 3 and 15 psi, there is a corresponding valve position.

Filter Size

Filtration might be considerably less expensive if the filter treatment plant could be built with fewer filter units. One of the first problems before the design engineer in attempting to design

square foot unit filtration rate. Some engineers feel that even a 5-gpm per square foot filtration rate is permissible with some waters.

It must also be understood that piping and concrete structure costs are usually lessened if the filter plant con-

sists of the fewest possible filter units. It is not permissible for the engineer to overlook continuity of service considerations when designing an economical filter plant. When permissible, however, some engineers are planning filter units in the total 15-mgd capacity range in order to lessen filtration plant costs.

The economical size of a filter unit is also controlled by back-wash piping

units are large. Some designers are therefore planning for wash water ground storage located on a hillside or upon built-up earth work immediately adjacent to the filter units. Also, when wash water piping is short, the total head of water required at the wash-water storage tank is appreciably less than is provided at some filtration plants.

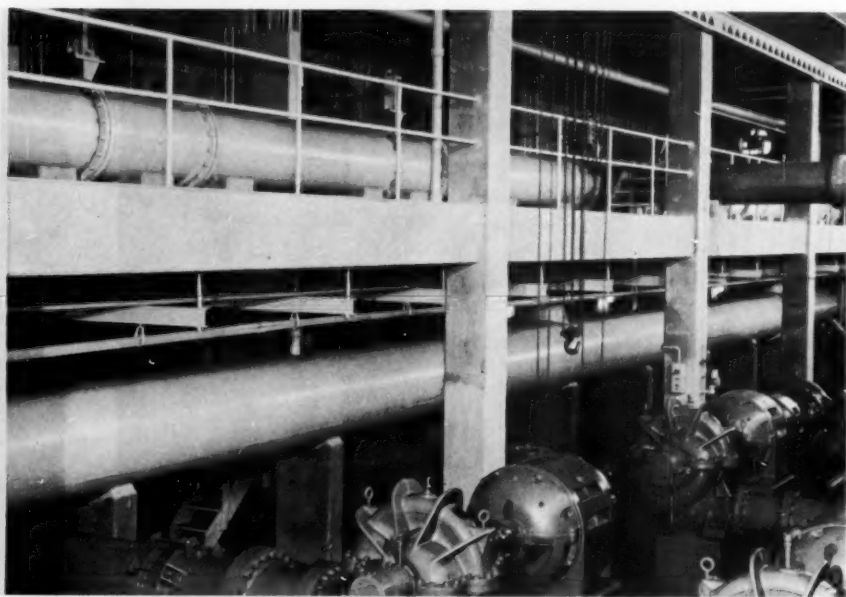


Fig. 3. Common Pump Room and Pipe Gallery

This type of combined pump room and filter pipe gallery holds building costs to a minimum.

and wash-water storage design considerations. The larger the filter, the larger the wash-water piping and wash-water storage required for each filter wash.

Other Modifications

Compared to ground tank storage, overhead-tank wash water storage is expensive, especially when the filter

Other important cost items in filter plant construction are the rate-of-flow controllers and other related instrumentation. Again, some engineers are honestly inquiring whether the conventional rate-of-flow controllers installed on filters are necessary to water quality. As a result, a number of engineers have borrowed from the flow control methods of the chemical industry and others

using industrial pneumatic controllers, pneumatic cylinders on butterfly valves, or diaphragm top valves, at a considerable saving (*see* Fig. 1). The Nelson Road plant in Columbus, Ohio, was built without any rate-of-flow controllers. Each filter is a part of the suction piping of a high-service pump. Filter effluent valves may sometimes double as rate-of-flow control valves, as shown in Fig. 2.

At the St. Louis County Water Company, filters are equipped with limiting rather than regulating rate-of-flow controllers. The amount of water filtered by each filter is controlled by the actual loss-of-head in the filter and the demand for water by the high-service pumps up to the designed capacity of the filter. (The high water level in the clear well is above the bottom of the filters.) If the filtration rate of any single filter tends to exceed the designed capacity of that filter, the rate-of-flow controller limits the filtration rate until the loss-of-head through that filter and the clear-well level limits the flow. An average of about 8 ft of pumping head is saved by this arrangement.

Filter plants have been costly to build because of the high cost of filter buildings. Consequently, more and more consideration is being given to out-of-door filters even in cold climates, and to functional control buildings (*see* Fig. 3) rather than ornamental museum-type structures. It is believed that filter plants can be attractive and

consistent with good public-relation policies even when the structures are functional and of the low, flat-roof, contemporary industrial design. Perhaps public relations could even be strengthened if the public were made to feel that money was not being wasted in ornamental structures.

There are other design features which should be periodically reviewed and weighed in terms of filter plant cost. The importance of wash troughs, for instance, is sometimes suspected as being overrated, and it is thought that they can perhaps be eliminated in some instances. Perhaps local river sands can be used for filter sand, rather than the graded specification sand obtainable from only certain suppliers. A few plants report successful use of Mississippi river sand containing an appreciable quantity of fine sand, some of which washes out during backwashing. It has been reported that finer or coarser sands than the often specified 0.4-0.5-mm sands can be used if the sand depth in the filter is correspondingly increased or decreased.

Reconsideration of these and other commonly accepted filter plant design practices is necessary if water treatment plant and operating costs are to remain consistent with revenues which are, or can be, obtained from the water-using public. Water quality and public health, however, must not be sacrificed when attempting to lessen filter plant costs.

New Developments in Tests of Coatings and Wrappings

—Graydon E. Burnett and Paul W. Lewis—

A paper presented on Jun. 15, 1955, at the Annual Conference, Chicago, Ill., by Graydon E. Burnett, Asst. Chief, Eng. Labs., and Paul L. Lewis, Head, Paint Lab., both of the Bureau of Reclamation, Denver, Colo.

THE laboratory and field tests of protective coatings, which are conducted by the Bureau of Reclamation, were first reported to AWWA in 1952 (1). The test coatings in Shasta Dam Penstock 5 have now been in service for over 5 years. Coatings under test at Shadow Mountain Reservoir have been exposed for as long as 4 years. In the laboratory, coatings and wrappings for buried pipe have been subjected to as many as 25 cycles of disruptive wetting and drying action of clay soil. During the time since test results were first reported, it has become possible to judge more accurately the potentialities of the test coatings for service.

Service experiences and data from other tests by the Reclamation Bureau have been added to this report to permit a more complete evaluation of the various protective coatings under consideration. Most of the coatings tested are proprietary products and the cooperation of the coating industry in furnishing materials and, in some instances, applying them has been an important factor in carrying out the test program.

In the interests of brevity, details of testing procedures given in the 1952 report are not repeated.

Shasta Dam Penstock Tests

The Shasta Dam tests were started in June 1949 when 20 different coatings, listed in Table 1, were applied in 26 systems to 160 lin ft of the interior of Penstock 5. All coatings were applied to sandblasted steel and have been almost continuously submerged in flowing water since then.

At the last inspection, October 1954, six of the 20 coatings showed no rust spots or film defects and are classified as Class *A* coatings. Six showed only very few rust spots and are considered Class *B* coatings. Three, showing numerous rust spots, are placed in Class *C*. One Class *B* coating applied in a thinner film is also listed as a Class *C* coating. The five coatings which permitted extensive rusting and were considered to have failed are placed in Class *D*.

All four of the phenolic paints under test are in Class *A*, along with one vinyl paint system and CA-50 coal-tar paint. One of the four phenolic paints is a red-lead paint very similar to that required under Federal Specification TT-P-86a, Type IV. The vinyl resin paint and CA-50 conform to Reclamation Bureau specifications. A six-coat vinyl resin paint conforming with bu-

reau specifications is placed in Class *B* because of two rust spots which occurred, but is practically a Class *A* coating. These coating materials are shown by this test to be serviceable for the interior of steel water piping and, for some exposures, may be found desirable substitutes for coal-tar enamel or cement-mortar linings. The length of the test, however, does not permit the conclusion that these coatings will have the durability of AWWA coal-tar enamel (which is in excellent condition in the remainder of the penstock) or cement mortar when those materials are used under favorable exposure conditions.

Two vinyl thiokol paints and a flame-sprayed thiokol, which are listed as Class *B* coatings, showed only a few rust spots on welds and in the invert. As noted before, a thinner application of one of the vinyl thiokol paints and a thin film of a vinyl containing stainless-steel pigment are in Class *C*.

A hot-applied, catalytically blown asphalt is rated Class *B*, but shows severe surface checking and rust at pinholes. The latter can be at least partially discounted because time did not permit normal patching of pinholes before placing the coating under test. So much water had been absorbed, however, that it could be squeezed out from the coating. A cold-applied synthetic-rubber paint is in Class *B*, having shown localized pinhead blisters and a few rust spots in the invert. Also, the top coat has peeled from a 1-sq ft area, indicating questionable adhesion between coats.

A zinc chromate fish-oil paint, applied as a thin film to sandblasted steel which was, at the manufacturer's request, purposely permitted to rust slightly, has numerous rust spots and

blisters and is in Class *C*. A coal tar-emulsion coating, whose thinner areas, especially, showed considerable pinhole rusting, is also in Class *C*. These coatings, as applied, would not be considered suitable for exposures such as those encountered in the present test. A thicker application of coal-tar emulsion, however, may have some merit where steel surfaces cannot be dried for effective application of a more durable coating.

The vinylidene acrylonitrile emulsion, flame-sprayed zinc wire, and flame-sprayed zinc powder were rated Class *D* in 1952. It should be noted that the zinc powder application was very thin. The microcrystalline wax and flame-sprayed plastic are now also Class *D* coatings because of development of extensive rusting and film degradation.

Shadow Mountain Low-Temperature Tests

These tests were started in February 1950 with the application of a number of interior linings and exterior coatings to 30-in. diameter steel pipe sections. Other coatings were applied later at convenient opportunities. During the winter months the coated-pipe sections were exposed to low atmospheric temperatures in the mountains of Colorado. In the summer, the sections were submerged in the inlet canal of Shadow Mountain Reservoir. Details of the Shadow Mountain tests are given in Tables 2 and 3.

Interior Linings

A cold-applied asphalt paint, the bureau's six-coat vinyl resin paint with and without a wash prime, and a brushed neoprene coating are in ex-

TABLE 1. Ratings of Test Linings in Shasta Dam Penstock as of October 1954

Type of Coating*	Coats						Average Dry-Film Thickness mils	Remarks
	1st	2nd	3rd	4th	5th	6th		
Class A—Coatings Showing No Rust Spots or Film Defects								
Phenolic paint†	Prime	Finish	Finish	Finish	Finish		4	
Red-lead phenolic paint†	Finish	Finish	Finish	Finish	Finish		5	
Red-lead phenolic paint†	Wash prime	Finish	Finish	Finish	Finish		8	
Red-lead phenolic paint†	Special oil	Finish	Finish	Finish	Finish		8	
Red-lead phenolic paint†	Wash prime	Finish	Finish	Finish	Finish		5	
Red-lead phenolic paint†	Special oil	Finish	Finish	Finish	Finish		5	
Coal-tar paint (CA-50)	Finish No. 1	Finish No. 1	Finish No. 2	Finish No. 2	Finish		20	
Vinyl resin paint	Finish No. 1	Finish No. 1	Finish No. 2	Finish No. 2	Finish		4.2	
Class B—Coatings Showing Not More Than a Few Rust Spots								
Flame-sprayed thiokol‡							31	Rusting at projections in metal and welds also in invert
Catalytically blown asphalt (metl)§							90	Severe surface checking; rust at pinholes. Coating absorbed water
Vinyl resin paint	Prime	Body No. 1	Body No. 1	Body No. 2	Seal		10	Rust spots on welds
Vinyl thiokol paint #	Prime	Prime	Finish	Finish			18	Rust spots in invert halfway to spring line
Synthetic rubber paint	Prime	Finish	Finish	Finish			9	Pinhead blistering; rust spots on invert; top coat peeled in 1-sq ft area
Vinyl thiokol paint	Prime	Finish	Finish	Finish			7	Rust spots in invert and on weld in arch
Class C—Coatings Showing Numerous Rust Spots								
Coal-tar emulsion	Finish	Finish	Finish	Finish			7	Pinhole rusting on invert and arch
Vinyl resin paint (stainless steel)	Prime	Finish	Finish	Finish			3.5	Rust spotting
Zinc chromate fish-oil paint	Prime	Prime	Prime	Prime	Finish		2.5	Rust spots and blistering
Vinyl thiokol paint	Prime	Prime	Prime	Prime	Finish		8	Rust spots in arch and extensive rusting in invert
Class D—Coatings Permitting Rusting on Over 25 per cent of Area (Failure)								
Microcrystalline wax (hot spray)†**	Prime						33	Extensive rusting as of October 1954
Flame-sprayed zinc wire††	Prime						33	Extensive rusting as of October 1954
Flame-sprayed zinc powder‡	Prime						1.7	Large rusted areas as of October 1951
Flame-sprayed plastic††	Prime						32	85% delamination as of October 1949
Vinylidene acrylonitrile emulsion	Finish	Finish	Finish	Finish			10	General film degradation; large rust areas as of October 1954
* Coatings are not listed in order of preference within classes. † Each group set off by brackets had the same coating but different surface treatments. ‡ One coat built up by multiple passes. § One coat built up by shingling with hand daubers. Finish coat built up by multiple passes. # Same coating applied in medium and thick films. ** Same coating applied over primed and unprimed surfaces. †† Finish coat built up by multiple passes.								

* Coatings are not listed in order of preference within classes.

† Each group set off by brackets had the same coating but different surface treatments.

‡ One coat built up by multiple passes.

§ One coat built up by shingling with hand daubers.

|| Same coating applied in medium and thick films.

Nine finish coats.

** Same coating applied over primed and unprimed surfaces.

†† Finish coat built up by multiple passes.

cellent condition after 4 years of exposure to temperatures which reached as low as -41°F . The vinyl resin paint is shown in Fig. 1. The CA-50 coal-tar paint showed slight surface checking in this period, but is otherwise in excellent condition. A vinyl thiokol paint has no defects after 39 months of exposure with a low temperature of -37°F . A wax cellulose paint shows general rusting where applied at 8-mil thickness, while the 17-mil coating



Fig. 1. Vinyl Resin Paint After Exposure

The paint is in excellent condition after 4 years of exposure. The discoloration is caused by sediment deposits.

shows surface checking and peeling over a quarter of the area. A 1.5-mil coating of zinc in an inorganic vehicle has allowed considerable rust spotting, whereas a 3-mil coating has permitted only a very small amount.

A microcrystalline-wax coating with and without a special primer failed after 1 year as a result of disbonding in cold weather. A cement-mortar lining with high water content cracked and disbonded after 14 months of exposure. A preshrunk, air-entrained cement mortar, however, is in excellent

condition after $3\frac{1}{2}$ years. It is apparent that mortar linings should be formulated for minimum drying shrinkage, especially if the lining will not be kept moist at all times. Table 4 lists mix data for the two mortars.

A red-lead phenolic paint (TT-P-86a, Type IV) and a coal-tar emulsion paint, both with and without a wash prime, are in excellent condition but have had less than 1 year of exposure. Coal-tar emulsion, when applied

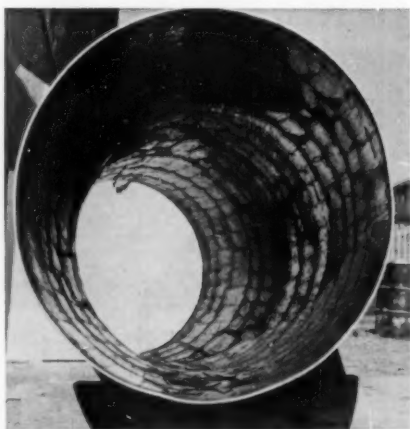


Fig. 2. Coal-Tar Enamel After Low-Temperature Exposure

Coal-tar enamels, with penetrations of $1\frac{1}{2}$ -5, cracked and spalled after exposure to -41°F .

to a damp surface, shows no defects in the 1-year period.

The AWWA coal-tar enamel, heated until it attained penetrations of $1\frac{1}{2}$ through 4 (2), failed from cracking and disbonding during the first winter of exposure to -41°F . A sample of the coal-tar enamel after exposure is shown in Fig. 2. Enamel with a penetration of 5 was only 1 per cent dis-

TABLE 2. Performance of Interior Linings in Shadow Mountain Low-Temperature Tests as of September 1954

Type of coating*	Coats						Average Dry Film Thickness mils	Submerged Exposure months	Atmospheric Exposure months	Temperature Exposed °F.	Remarks
	1st	2nd	3rd	4th	5th	6th	7th				
Coal-tar paint (CA-50)	Finish	Finish	Finish					15	16	40	Localized checking
Cold-applied asphalt paint	Finish	Finish	Finish					34	16	40	No defects
Vinyl resin paint	Prime	Body No. 1	Body No. 2	Body No. 1	Seal	Seal	Seal	12.5	20	27	No defects
Vinyl resin paint	Wash prime	Prime	Body No. 1	Body No. 2	Body	Body	Body	12.5	20	27	No defects
Vinyl resin paint	Prime	Prime	Body	Body				18	20	27	No defects
Neoprene	Prime	Prime	Finish	Finish				40	20	27	No defects
Vinyl thiokol paint	Prime	Finish	Finish	Finish				7	20	19	No defects
Vinyl thiokol paint	Prime	Finish	Finish	Finish				6	20	19	No defects
Wax cellulose paint	Prime	Finish	Finish					17	20	27	25% surface checking and peeling
Wax-cellulose paint	Finish	Finish	Finish					8	16	40	General rusting
Zinc in inorganic vehicle	Finish	Finish	Finish					3	20	19	Very small areas
Zinc in inorganic vehicle	Finish	Finish	Finish					1.5	20	19	Rust spots 1 1/2 ft in area
Microcrystalline wax	Prime	Finish	Finish					120	3	8	Cracking and disbonding
Microcrystalline wax	Prime	Finish	Finish					87	3	8	Cracking and disbonding
Cement mortar	One coat built up with trowel							300	4	10	Shrinkage, cracking, and disbonding
Preshrunk cement mortar	One coat built up with trowel							300	12	29	Few hairline cracks; no rust; coating bonded
CTE, (1)	Prime		Finish ‡					128	0	5	General cracking and disbonding
CTE, (2)	Prime		Finish ‡					130	0	5	General cracking and disbonding
CTE, (3)	Prime		Finish ‡					110	0	5	General cracking and disbonding
CTE, (4)	Prime		Finish ‡					110	0	5	General cracking and disbonding
CTE, (5)	Prime		Finish ‡					70	20	27	General cracking and disbonding
CTE, (6)	Prime		Finish ‡					97	20	27	General cracking and disbonding
CTE, (7)	Prime		Finish ‡					93	20	27	General cracking and slight disbonding
CTE, (9)	Prime		Finish ‡					80	20	27	Slight cracking
CTE, (10)	Prime		Finish ‡					78	20	27	Slight cracking
Red-lead phenolic paint	Finish	Finish	Finish	Finish				5.5	4	4	No defects
Red-lead phenolic paint	Finish	Finish	Finish	Finish				4	4	4	No defects
Red-lead phenolic paint	Wash prime	Finish	Finish	Finish				5.5	4	4	No defects
Coal-tar emulsion (damp surface)	Wash prime	Finish	Finish	Finish				12	4	4	No defects
Coal-tar emulsion (damp surface)	Wash prime	Finish	Finish	Finish				14	4	4	No defects
Coal-tar emulsion (damp surface)	Finish	Finish	Finish	Finish				13	4	4	No defects

* Coatings are not listed in order of preference. CTE indicates coal-tar enamel and values in parenthesis indicate penetration of enamel.

† Twelve coats.

‡ Finish coat built up by shingling with hand daubers.

bonded, while that with penetrations of 9 and 10 was unaffected by this low temperature. In 4 years of exposure, general cracking has developed in enamel with penetration up to 7, and there has been slight cracking in the enamel with penetrations of 9 and 10. It is concluded that plasticity is highly important if enamel is to be exposed to cold. The bureau for some time has been specifying a minimum penetration of 7, as applied, and does not ordinarily use enamel where temperatures will go below -20°F . The bureau's latest specifications require a minimum penetration of 9, because experience has shown that this requirement can be readily met.

Exterior Coatings

Although a longer test period is required before final conclusions can be drawn with respect to the exterior coatings applied to the test sections, the following tentative appraisal is indicated for coatings having undergone approximately 4 years of test:

1. Phenolic vehicles show general superiority over the other oleoresinous vehicles tested, as used both in the prime coat and in aluminum finish coats. Best performance so far has been obtained where phenolic vehicle is used for both primer and finish coats of a system.

2. Oleoresinous-paint systems, consisting of primers of red lead in linseed oil (TT-P-86a, Type I), red-lead alkyd (TT-P-86a, Type II), red-lead alkyd linseed oil (TT-P-86a, Type III), and iron-oxide zinc chromate alkyd (TT-P-636) followed by either regular aluminum paint (vehicle TT-V-81a), or phenolic aluminum paint (vehicle TT-V-119), show defects ranging from slight pinpoint blistering to general pinhead blistering.

3. A rust-inhibitive wash aids considerably in the performance of the phenolic-zinc chromate aluminum paint system.

4. A definite advantage of sandblasting over power wire brushing for surface preparation is seen in the superior bond of the paint coatings where the surface was cleaned by sandblasting, as shown in Fig. 3.

A vinyl mastic, a phenolic-paint system, and a petroleum resin gilsonite paint are giving excellent performance



Fig. 3. Power Wire-brushed and Sandblasted Surfaces

Foreground of right pipe and background of left show paint peeling over power-wire brushed surfaces. The other areas were sandblasted and show improved performance of paints.

over a 39-month period. A vinyl thiokol paint shows slight blistering after the same period of exposure.

It should be noted that, because of the extended submersion periods, the exposure in this test was more severe than would be usual for the exterior of steel water pipe exposed to nonindustrial atmospheres. Condensation frequently occurs on exposed cold-water lines, however, and the test results may be indicative of comparative performance on such lines.

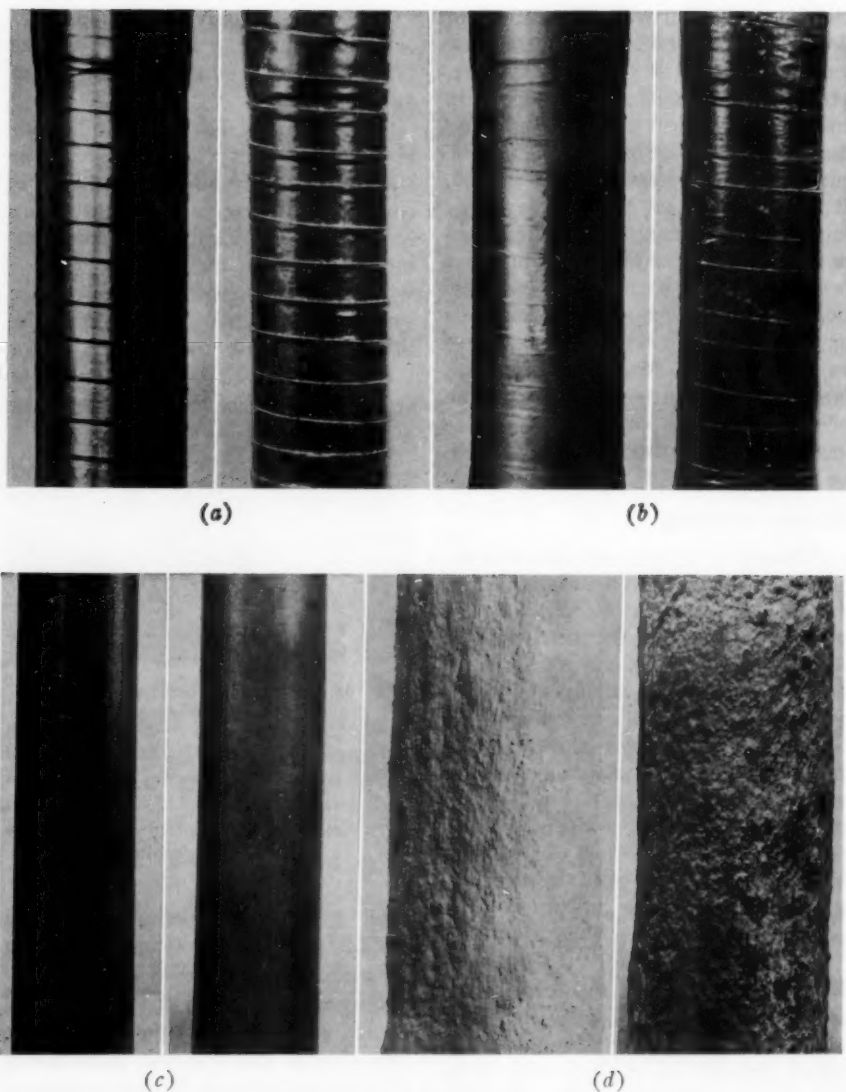


Fig. 4. Buried-Pipe Test Samples Before and After Exposure

The type and thickness of coating and the number of cycles to which the sample had been exposed are: (a) vinyl tape, 20 mil, 25 cycles; (b) polyethylene tape, 10 mil, 25 cycles; (c) vinyl resin paint, 10 cycles; (d) cement mortar, 25 cycles.

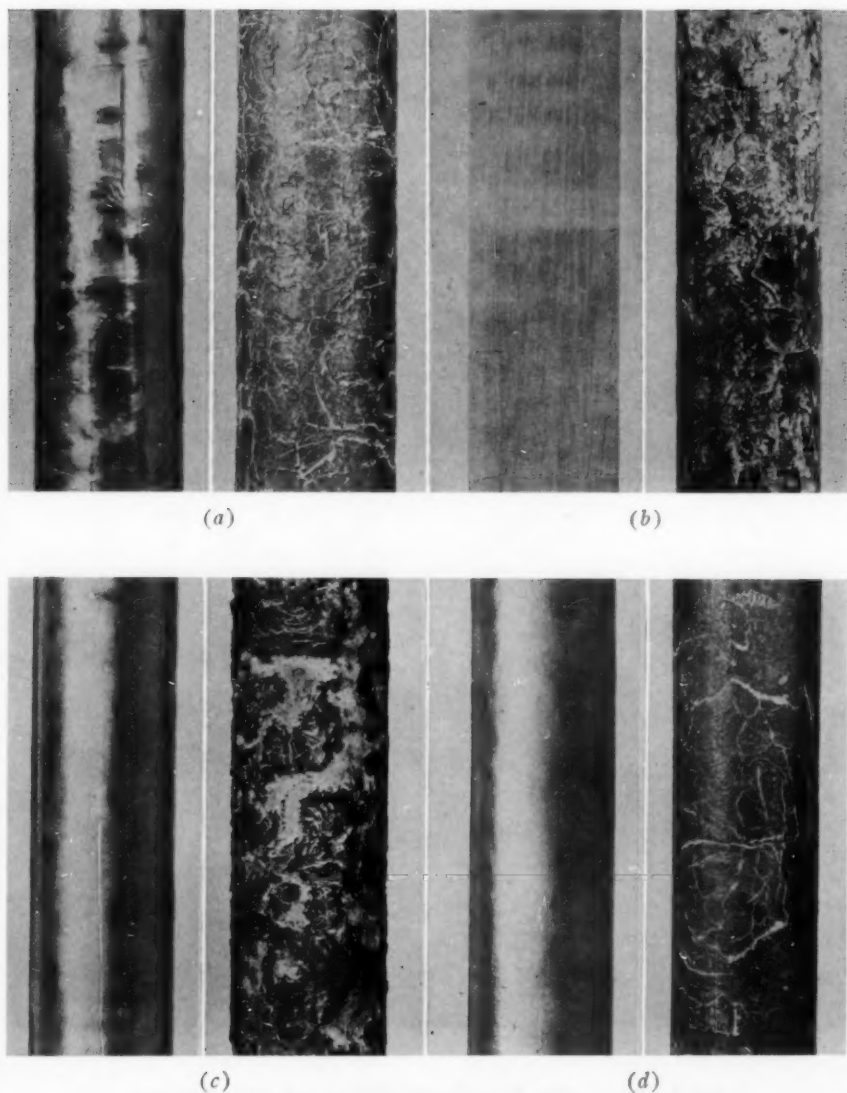


Fig. 5. Buried-Pipe Test Samples Before and After Exposure

The type of coating and the number of cycles to which the sample had been exposed are: (a) coal-tar enamel, 10 cycles; (b) coal-tar enamel with whitewash, 25 cycles; (c) asphalt enamel, 10 cycles; (d) CA-50 coal-tar paint, 10 cycles.

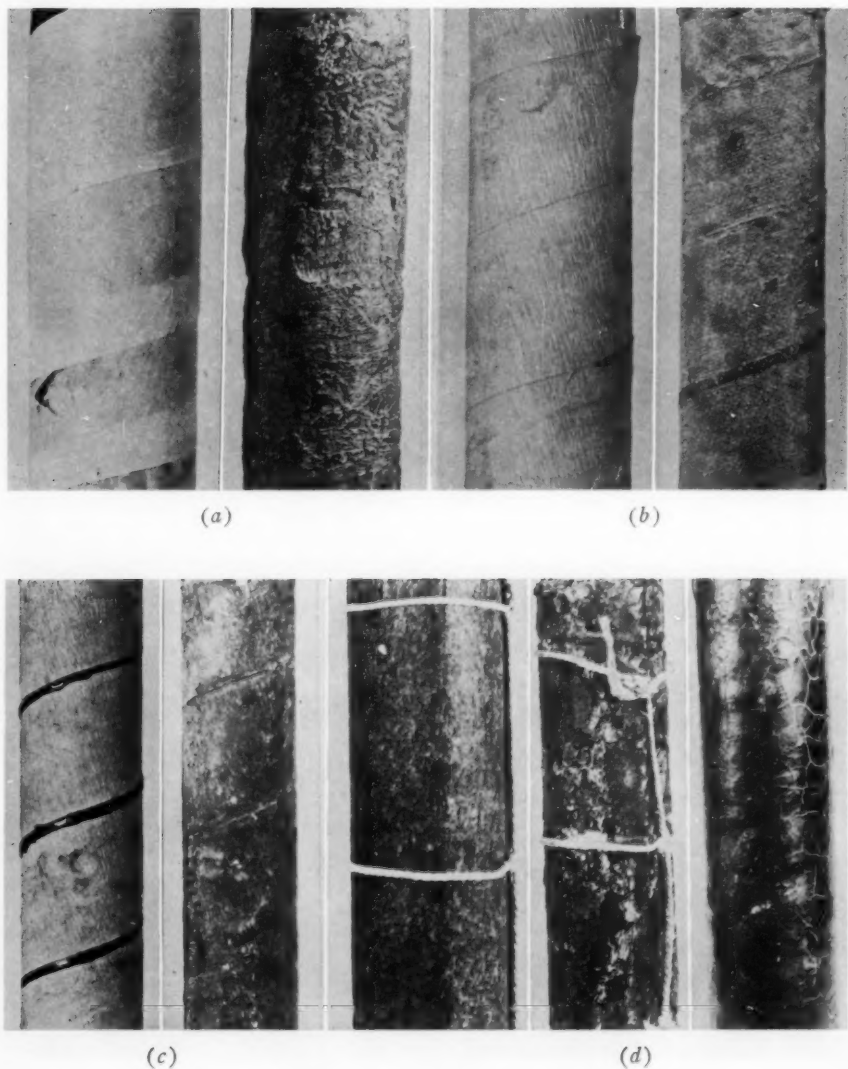


Fig. 6. Buried-Pipe Test Samples Before and After Exposure

The type of coating and the number of cycles to which the sample had been exposed are: (a) glass-reinforced coal-tar wrap with paper wrapper, 25 cycles; (b) glass-reinforced coal-tar enamel with bonded asbestos felt and crinkle kraft wrap, 25 cycles; (c) glass-reinforced coal-tar enamel with crinkle kraft wrap, 25 cycles; (d) coal-tar enamel with $\frac{1}{8}$ -in. rock shield, 14 cycles (shown before and after removal of shield).

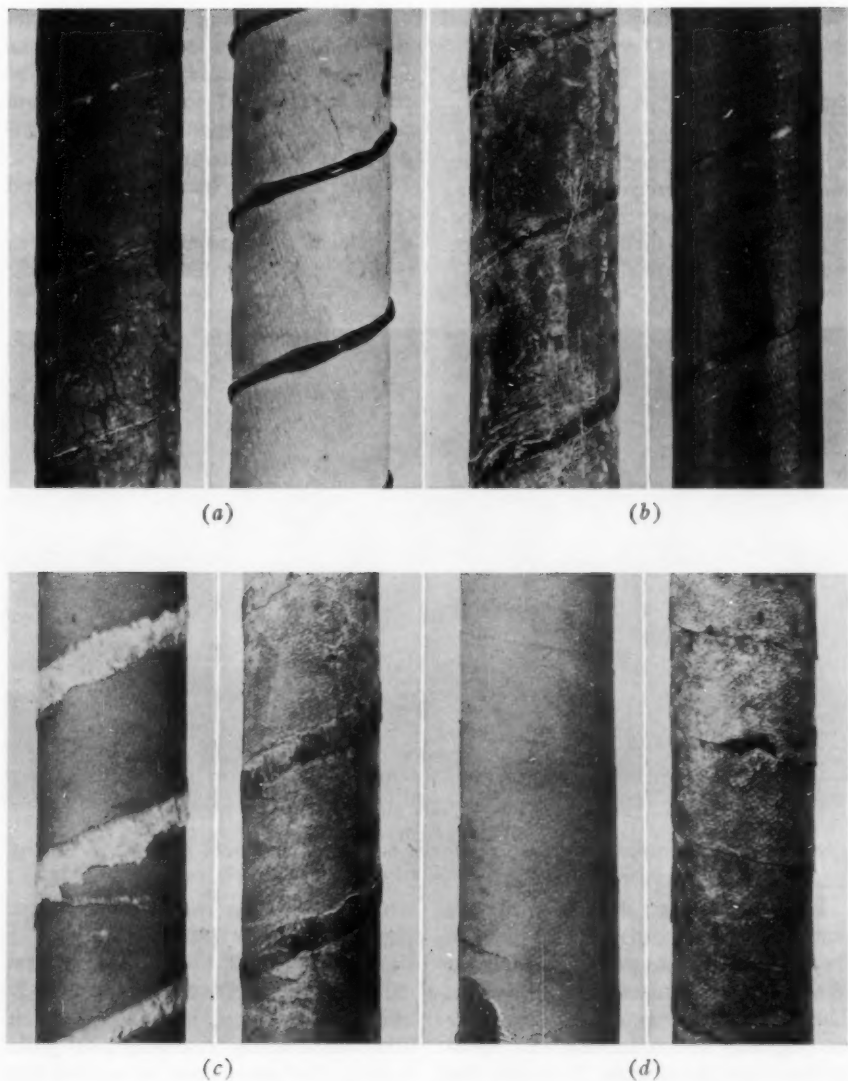


Fig. 7. Buried-Pipe Test Samples Before and After Exposure

The type of coating and the number of cycles to which the sample has been exposed are: (a) microcrystalline wax with microcrystalline wax-impregnated laminated wrap, 25 cycles; (b) coal-tar enamel with crinkle kraft wrap, 25 cycles; (c) coal-tar enamel with bonded asbestos felt, 25 cycles; (d) asphalt enamel with bonded asbestos felt, 25 cycles.

Coatings and Wrappings for Buried Pipe

Bureau tests on exterior coatings and wraps consist of exposing them to alternate wetting and drying of clay soils and to an indentation test. Test specimens are prepared by applying coatings and wraps to 18-in. long sections of 3½-in. diameter steel pipe. Sample sections are shown in Fig. 4-7.

In the indentation test, which is designed to measure relative resistance to such punctures as those caused by rocks in backfill, a load of 6.48 lb on the flat end of a ¼-in. steel rod is imposed on the coating and held at 73.4°F until movement of the rod ceases. The extent of indentation is then measured and the indented area is given a holiday detection test to see



Fig. 8. Test Bed for Soil Tests on Coatings and Wrappings

The coated and wrapped samples are shown before being buried in the clay slurry.

For the soil test, the specimens are buried in a clay slurry which is then thoroughly dried to produce soil stress effect through contraction of the clay. The test bed is shown in Fig. 8. One wetting and drying of the clay comprises a cycle. Figure 9 shows the test bed after the clay has been thoroughly dried. The clay is a "lean" type, with a liquid limit of 40.4, a plasticity index of 21.1, and a shrinkage limit of 14.6. At intervals the coatings are checked for breaks and pinholes with an electrical holiday detector.

if the coating has ruptured. The apparatus for the indentation test is shown in Fig. 10.

Data on the soil stress and indentation tests are given in Table 5, which lists the coating systems, and gives coating thicknesses and results of the holiday detection tests. In all the test coatings, the coal-tar enamel, asbestos felt, kraft paper, and cement mortar used conformed with AWWA specifications (3).

The following coatings performed effectively through 25 wetting and dry-

ing cycles and passed the indentation test: [1] coal-tar enamel, glass mat, coal-tar enamel, felt, kraft paper; [2] coal-tar enamel, glass mat, coal-tar enamel, kraft paper; [3] coal-tar enamel, glass mat, coal-tar enamel, glass-mat outer wrap, kraft paper; [4] double wrap of coal-tar enamel, glass-fabric tape, paper; [5] coal-tar enamel, cement mortar; [6] cement mortar; [7] vinyl tape (20 mils); [8] plasticized

them in this group. The failures in each case occurred where the wrapping did not overlap properly.

The following coatings performed effectively through at least 15 wetting and drying cycles and passed the indentation test (the coal-tar enamel, with the rock shield failed the holiday test after 14 cycles, however): [1] coal-tar enamel, felt, kraft paper; [2] polyethylene tape (10 mils); [3]

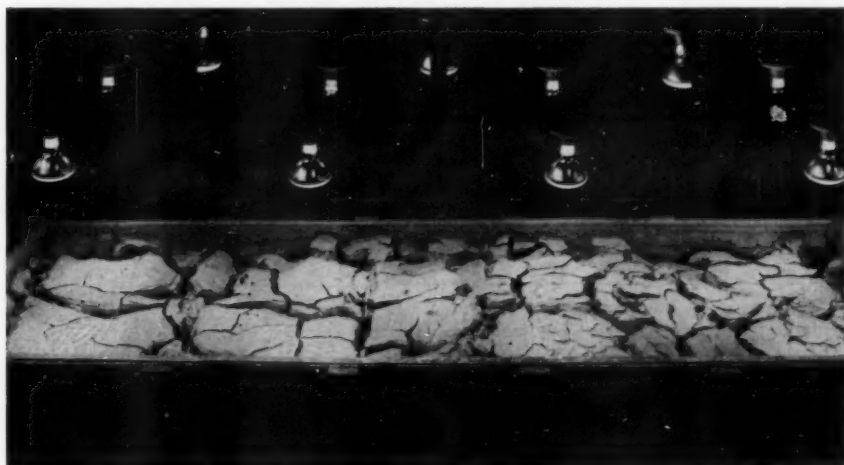


Fig. 9. Test Bed After Clay Slurry Has Been Thoroughly Dried

Drying of the clay soil results in contraction, which produces soil stress effects.

gilsonite, glass mat, gilsonite, wax-impregnated laminated wrap; [9] plasticized gilsonite, wax-impregnated laminated wrap; and [10] microcrystalline wax, wax-impregnated laminated wrapper.

As noted in Table 5, three specimens in this group failed in the holiday detection test after 20 or 25 wetting and drying cycles, but these failures were all due to obviously faulty application of wrappings in limited areas and it is believed proper to include

asphalt enamel, felt; and [4] coal-tar enamel, $\frac{1}{8}$ -in. rock shield.

The following coatings failed in 6 or less wetting and drying cycles or failed the indentation test or failed in both: [1] coal-tar enamel, kraft paper; [2] coal-tar enamel, glass-mat outer wrap; [3] coal-tar enamel, whitewash; [4] coal-tar enamel; [5] coal-tar pitch, organic-fabric tape wrap; [6] CA-50 coal-tar paint; [7] asphalt enamel; [8] reclaimed rubber tape; and [9] gilsonite base paint.

TABLE 3. Performance of Exterior Coatings in Shadow Mountain Low-Temperature Tests as of September 1954*

Prime Coat	Coating system*†	Finish Coats	Surface Preparation	Average Dry Film Thickness mils	Exposure—months		Remarks
					Submerged	Atmospheric	
Phenolic red lead‡	2 coats Al††		pwr	3.5	20	27	Slight pinpoint blistering; bond fair
Phenolic red lead‡	2 coats phenolic Al††		pwr	3.5	20	27	No defects; bond fair
Phenolic red lead‡	2 coats Al††		sb	3.5	20	27	General pinpoint blistering; bond excellent
Phenolic red lead‡	2 coats phenolic Al††		sb	3.5	20	27	No defects; bond excellent
Red-lead paint§	2 coats Al††		pwr	3.5	20	27	General pinhead blistering; bond poor
Red-lead paint§	2 coats phenolic Al††		pwr	3.5	20	27	General pinhead blistering; bond poor
Red-lead paint§	2 coats Al††		sb	3.5	20	27	General pinhead blistering; bond good
Red-lead paint§	2 coats phenolic Al††		sb	3.5	20	27	Slight pinhead blistering; bond good
Red-lead paint	2 coats Al††		pwr	3.5	20	27	General pinhead blistering; bond fair
Red-lead paint	2 coats phenolic Al††		pwr	3.5	20	27	General pinpoint blistering; bond fair
Red-lead paint	2 coats Al††		sb	3.5	20	27	General pinhead blistering; bond good
Red-lead paint	2 coats phenolic Al††		sb	3.5	20	27	General pinhead blistering; bond good
Red-lead paint#	2 coats Al††		pwr	3.5	20	27	Severe pinhead blistering; bond fair
Red-lead paint#	2 coats phenolic Al††		pwr	3.5	20	27	Slight pinpoint blistering; bond fair
Red-lead paint#	2 coats Al††		sb	3.5	20	27	General pinhead blistering; bond good
Red-lead paint#	2 coats phenolic Al††		sb	3.5	20	27	General pinhead blistering; bond good
Priming paint**	2 coats Al††		pwr	3.5	20	27	Severe pinhead blistering; bond poor
Priming paint**	2 coats phenolic Al††		pwr	3.5	20	27	Slight pinhead blistering; bond poor
Priming paint**	2 coats Al††		sb	3.5	20	27	No defects; bond poor
Priming paint**	2 coats phenolic Al††		sb	3.5	20	27	No defects; bond poor
Zinc chromate (Al) paint	2 coats Al††		pwr	5	20	27	General pinhead blistering; bond poor
1 coat rust inhibitive wash and 1 coat zinc chromate (Al) paint	2 coats Al††		pwr	5	20	27	No defects; bond poor
Zinc chromate (Al) paint	2 coats phenolic Al††		pwr	5	20	27	Slight pinhead blistering; bond poor
1 coat rust inhibitive wash and 1 coat zinc chromate (Al) paint	2 coats phenolic Al††		pwr	5	20	27	No defects; bond poor
Zinc chromate (Al) paint	2 coats Al††		sb	5	20	27	General pinhead blistering; bond good
1 coat rust inhibitive wash and 1 coat zinc chromate (Al) paint	2 coats Al††		sb	5	20	27	No defects; bond excellent
Zinc chromate (Al) paint	2 coats phenolic Al††		sb	5	20	27	General pinhead blistering; bond good
1 coat rust inhibitive wash and 1 coat zinc chromate (Al) paint	2 coats phenolic Al††		sb	5	20	27	No defects; bond excellent
Vinyl primer	4 coats vinyl thiokol paint		pwr	6.4	12	27	Slight pinhead blistering; bond fair
	4 coats petroleum resin gilsonite paint		pwr	8	12	27	No defects; bond fair
	Vinyl mastic paint		sb	20	12	27	No defects; bond good
	3 coats phenolic paint system		pwr	4	12	27	No defects; bond poor
	3 coats phenolic paint system		sb	4	12	27	No defects; bond good
	6 coats phenolic paint system		sb	6	12	27	No defects; bond good

* Abbreviations used in the table are: Al indicates aluminum pigment; pwr indicates power wire brushing; sb indicates sandblasting.

†† Coatings are not listed in order of preference. Paints shown as same kind or type are the same materials.

‡ TT-P-86a, Type IV.

§ TT-P-86a, Type I.

|| TT-P-86a, Type III.

TT-P-86a, Type II.

** TT-P-86a, Type I.

†† TT-V-51a.

‡‡ TT-V-119.

The tests show that bituminous enamels should be protected by a shielding wrap or glass-mat reinforcement to preserve their continuity in wetting and drying clay soils. Although glass-mat reinforcement prevents disruption of the enamel beneath the glass mat, the effective coating thickness is reduced. To be effective as reinforcement, therefore, the glass mat should be thoroughly imbedded in

bead was formed and then flattened by wrapping with kraft paper, the bead was less affected than where it was not flattened.

Both whitewash and bonded kraft paper provide temporary protection against soil stress. In this test, the whitewash was renewed after each inspection, because it was removed in washing the specimen for examination. For this reason, whitewash gave

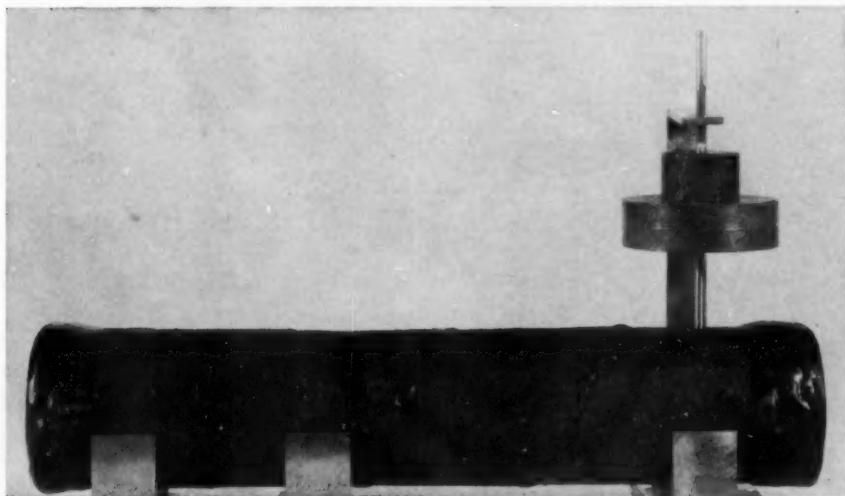


Fig. 10. Indentation-testing Apparatus

The flat end of a $\frac{1}{4}$ -in. steel rod transmits a load of 6.48 lb on the coating and the test is continued at 73.4°F until movement of the rod ceases.

the enamel but it should not be drawn more than about halfway through the enamel coating.

It was found that asbestos felt wrapping over enamel must be overlapped and thoroughly bonded to the enamel to avoid disruption by soil stress. Also, the felt was disrupted where no enamel bead was formed at the overlap during application. Where such a

better protection under test than could be expected in service. The kraft paper was gradually stripped by the soil to a point where cracking developed rapidly. In the soil tests, no difference was observed in the performance of coal-tar enamel, with penetrations of 4, 7, or 8.

A double wrap of glass-reinforced coal tar-enamel tape provided complete



Fig. 11. Cement-Mortar Lining After Exposure

Cement-mortar lining with high water content cracked and spalled after 14 months of service.

protection, even though disruption of the top wrap of the specimen developed. The 20-mil vinyl tape showed more resistance to damage from soil stress than the 10-mil polyethylene tape, which is probably caused more by difference in thickness than by difference in material. Both tapes resisted puncture in the indentation test. Slight rusting was observed where the tapes were applied to bare metal, but not where they were applied over coal-tar primer.

The microcrystalline-wax and plasticized-gilsonite coatings were well protected by a wax-impregnated wrapper, although considerable distress in the wrapper had occurred by 25 cycles. Cement mortar was unaffected by soil stress, and the observed hairline cracking undoubtedly resulted from drying shrinkage.

Some of the coatings have not been under test long enough to warrant a final rating. These include two vinyl resin paint systems and a phenolic-

resin red-lead paint system (TT-P-86a, Type IV) which are providing excellent resistance to soil stress as far as they have been tested. It was observed that when the phenolic-resin red-lead coating was allowed to harden for only 5 days before subjecting to test it was severely disrupted in the first cycle of the test. The phenolic-resin red-lead specimen still under test was allowed to harden 30 days. The 5-day drying time for vinyl resin paint, as specified by the bureau, and for the vinyl mastic proved adequate for effective hardening. The vinyl resin and phenolic-resin red-lead paints were not damaged in the indentation test. Asbestos felt bonded to galvanized corrugated metal also is showing good resistance to soil stress after 14 wetting and drying cycles and was not damaged by the indentation test.

Plastic Tape Wraps

In recent years, much interest has been shown in vinyl and polyethylene plastic tapes for use in protecting the exterior of steel pipe. These tapes possess an advantage over hot coatings in that they are easier to apply, especially in coating welded field joints. In addition to the buried-pipe tests, other tests were made on plastic tapes. One test was the laboratory salt crock test, which is an impressed-voltage, electrolytic coating-resistance test. The other test was an adhesion test, which is a modification of ASTM designation D1000 (4). Results observed in these two tests were:

1. Single, half-lapped wrappings of 10-mil vinyl and 10-mil polyethylene tapes, applied to straight sections of pipe, maintained a resistance of 30×10^6 ohms in the salt crock test for 30 months.

2. Attempts to obtain a tight seal and high resistance in the salt crock test when applied over fittings have been generally unsuccessful. Recent tests indicate, however, that, if plastic fillers to fill the offsets created by the fittings are used before applying the tape, they may solve the problem.

3. Primers have shown to advantage in the use of plastic tapes. They improve adhesion, especially in the case

TABLE 4
Cement Mortar for Shadow Mountain Tests

Item	Mix No. 1*	Mix No. 2†
Water-cement ratio (by weight)	0.95	0.45
Air Content—% (by volume)	None	0.02
Aggregate—cumulative percentage passing sieve:		
No. 16	100.0	82.7
No. 30	64.4	40.0
No. 50	29.7	10.0
No. 100	7.0	0.0
Pan	0.0	
Curing	kept moist 12 hr	kept moist 7 days

* Mix No. 1 consisted of 1 part Type I cement, 0.25 part diatomaceous earth, and 1.25 parts sand. It was applied immediately after mixing.

† Mix No. 2 consisted of 1 part Type II cement, and 2 parts sand. It was mixed for 5 minutes, allowed to stand in mixer for 1 hour, and then remixed for 5 minutes.

of vinyl tapes applied at cold temperatures, and minimize a tendency for rusting at tape overlaps.

4. Tapes must be wrapped smoothly so that the wrapping will have no channels that will enable moisture to contact the steel. Because of the reduced plasticity of the tapes, smooth wrappings were more difficult to obtain when applying tapes at cold temperatures.

TABLE 5. Performance of Exterior Pipe Coatings and Wraps in Clay Soil and Indentation Tests

Coating System*	Average Dry Film Thickness mils	Detector Test After Wetting and Drying	Detector Test After Indentation	Remarks
CTE (8)	130	Failed 4 cycles	Fail	Deep cracks; bare metal exposed
CTE (8), kraft wrap	120	Failed 6 cycles	Pass	95% of bead disbanded; numerous cracks in enamel; kraft gone
CTE (7), felt, kraft wrap	185	Failed 25 cycles	Pass	Tearing of felt; one piece of improperly bonded felt torn off (one holiday in this area); felt disrupted where no bead
CTE (8), white wash†	130	Failed 25 cycles	Fail	Considerable checking and cracking
CTE (7), glass mat outer wrap	145	Passed 25 cycles	Pass	Bead gone; cracking enamel down to glass mat; kraft gone
CTE (7), glass mat outer wrap	95	Failed 15 cycles	Fail	Glass mat exposed on 80% of wrapper peeled to glass core; cracking at butt edges of wrap; bead gone
CTE (7), glass mat, CTE, felt, kraft wrap	185	Passed 25 cycles	Pass	Felt disrupted where no bead; bead 60% gone; kraft gone
CTE (8), cement mortar	1 in.	Passed 25 cycles	Pass	Hairline crack in mortar; sealing compound removed
CTE (4)	95	Failed 3 cycles	Fail	Deep cracks; bare metal exposed
CTE (4), felt, kraft wrap	100	Failed 20 cycles	Pass	Tearing of felt; felt butted instead of overlapped (holidays located in this area)
CTE (4), glass mat, CTE, felt, kraft wrap	125	Failed 20 cycles	Pass	Felt torn; enamel cracked in one area where felt was butted
CTE (4), glass mat, CTE, glass-mat outer wrap, kraft wrap	145	Failed 20 cycles	Pass	50% of wrapper peeled to glass core; crack in enamel at butt edges of outer wrap
Asphalt enamel	85	Failed 3 cycles	Fail	Severe cracks and disruption; bare metal exposed
Asphalt enamel, felt	155	Failed 20 cycles	Pass	Tearing of felt; general loosening and tearing of felt at overlaps where bead was not formed
CA-50 coal-tar paint	25	Failed 4 cycles	Fail	Cracked and alligatored to bare metal
Cement mortar	1 in.	Passed 25 cycles	Pass	Several hairline cracks; no rust; sealing compound removed
Polyethylene tape (10 mil)	20	Failed 25 cycles	Pass	Considerable wrinkling of tape; pinholes at overlap where tape had been stretched
Vinyl tape (20 mil)	40	Passed 25 cycles	Pass	Slight wrinkling
Plasticized gilsonite, wrap‡	140	Failed 25 cycles	Pass	80% of bead gone; wrapper torn; pinholes near end of specimen due to wrapper not overlapping
Microcrystalline wax, wrap‡	125	Passed 25 cycles	Pass	Bead gone; wrapper torn
CTE, glass-fabric tape, double wrap, paper	70	Passed 25 cycles	Pass	Bead gone; wrapper torn
Reclaimed rubber tape	175	Passed 25 cycles	Pass	Glass fabric exposed in several places; paper gone
CTE (4) 1-in. rock shield	50	Failed 5 cycles	Fail	Deep cracks; bare metal exposed
Coal-tar organic-fabric tape wrap	220	Failed 14 cycles	Pass	Shield torn away in several places; cracks in enamel
Gilsonite base paint	160	Failed 4 cycles	Fail	Deep cracking
Galvanized corrugated iron, asphalt dip	7	Test not applicable	Test not applicable	Paint peeled from metal in spots; considered to have failed in 4 cycles
Galvanized corrugated iron, asbestos bonded§	22	Test not applicable	Test not applicable	95% of asphalt gone; considered to have failed in 4 cycles
Galvanized corrugated iron§	3.5	Test not applicable	Test not applicable	Slight tearing of felt; still passing at 14 cycles
Galvanized corrugated iron§	0.5	Test not applicable	Test not applicable	Reaction products formed on metal surface; no effect from soil stress at 14 cycles
Galvanized corrugated iron, asbestos bonded, asphalt dip§	25.5	Test not applicable	Test not applicable	75% of asphalt gone; felt essentially intact at 14 cycles
Vinyl tape (10 mil)§	20	Passed 14 cycles	Pass	Considerable wrinkling of tape at overlaps
Vinyl mastic paint, 1 prime coat, 1 finish coat§	30	Test not applicable	Test not applicable	Superficial defects at 10 cycles
Phenolic red lead, TT-P-86a, Type IV, 3 coats§	8	Test not applicable	Test not applicable	Superficial defects at 8 cycles
Vinyl resin paint (single solution), 3 coats§	7	Test not applicable	Test not applicable	Superficial defects at 10 cycles

* Coatings are not listed in order of preference. CTE indicates coal-tar enamel, and values in parenthesis indicate penetration of enamel.

† White wash renewed after each cycle.

‡ Microcrystalline wax-impregnated laminated wrapper.

§ Test continuing.

¶ Defects attributable to faulty application.

|| Unless otherwise noted.

Some of the difficulties indicated in the laboratory tests have been experienced in field applications of tapes on bureau projects. When vinyl tape was applied at low temperatures, less effective bonding was obtained and there was some cracking caused by brittleness. Difficulty was experienced with both vinyl and polyethylene tapes in obtaining leakproof wrappings over abrupt surface irregularities. Also, during storage of coated pipes in hot weather, both tapes tended to be damaged at points of contact with skids.

On one bureau project, a vinyl plastic-tape wrapping on 2½-in. diameter buried steel piping was uncovered after 3 years of service and found to be in good condition and to be providing excellent protection for the steel.

Glass-Mat Reinforcement for Coal-Tar-Enamel Coatings

In addition to the favorable record of glass-mat reinforcement obtained in the buried-pipe tests, the bureau has had good experiences with this type of wrapping in service applications.

The value of glass reinforcement for preventing cracking of coal-tar enamel was well demonstrated when it was used in conjunction with an extra-thick coal tar-enamel coating on a 13-mile steel pipe casing for an electrical transmission line extending through a water tunnel. The steel piping was coated in Denver and transported by truck to the tunnel site in the mountains above Estes Park, Colo. Installation was carried on in the winter and the piping was unavoidably flexed at near-zero temperatures. Holiday detection tests indicated a minimum of damage to the coating from the installation operations. In-

spection of 1 mile of the coated pipe 2 years after installation revealed no defects.

In another instance, a glass-reinforced coal tar-enamel coating was applied to the exterior of a 48-in. steel siphon. Some of this piping was installed in cold weather at temperatures below 10°F, with only minor installation damage to the coating.

In bureau service applications of glass-reinforced coal tar-enamel coat-

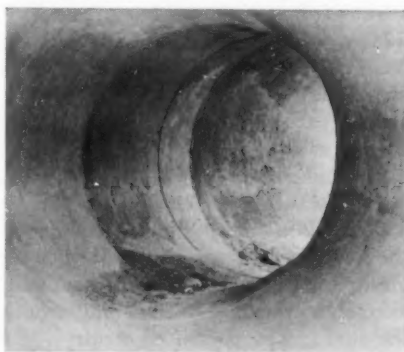


Fig. 12. Preshrunk, Air-entrained Cement-Mortar Lining

Except for a few hairline cracks, the lining is in excellent condition after 3½ years of exposure.

ings, there was practically no bubbling in the enamel coating during application and vapor pockets were at a minimum. Also, little difficulty was experienced with wrinkling of the wrapping caused by uneven application.

Cement Mortar

Data obtained in the buried-pipe tests show that cement mortar possesses excellent resistance to soil stress. In the Shadow Mountain low-temperature tests, where it was tested as a lining

material, cement mortar of high water content cracked and disbonded when allowed to dry during atmospheric exposure. These effects are shown in Fig. 11. A preshrunk, air-entrained cement-mortar lining, exposed for 3½ years, however, has only a few hair-line cracks with no disbonding or rusting of the steel, as shown in Fig. 12.

In a field test on a cement-mortar lining applied to the interior of a 10-ft diameter exposed siphon, the lining has developed serious cracking and spalling after 4 years of service. The mortar was of normal quality, but was unable to withstand the repeated drying shrinkage to which it was subjected each winter during the off-irrigation season.

One and one-half years ago an experiment with cement-mortar lining was tried in another large siphon in the Northwest to see whether wire mesh reinforcement would eliminate excessive cracking and spalling where the lining was permitted to dry. So far there has been no spalling, and there have been only hairline cracks. More time is needed for final evaluation, however.

In recent years, the bureau has used cement mortar to a considerable extent for protecting the interior of steel piping where the pipe is buried and usually kept filled with water. Also, the bureau has used reinforced, pneumatically placed mortar as an exterior coating for buried steel pipe for many years.

Other Developments

An interesting research field exists in the study of the possibilities of synthetic-rubber coatings used for protection of steel, particularly where the steel is exposed to cavitation ero-

sion. As compared with vinyl and coal-tar paints, Neoprene and flame-sprayed thiokol have shown superior resistance to cavitation erosion in laboratory tests. Although limited field tests of these coatings as applied to turbine runners have not been very successful, it still seems that rubber coatings have good potentiality for service under cavitation conditions. Brushed neoprene coatings have also shown excellent performance in salt-spray and fresh-water laboratory tests. Thus, rubber coatings may find application for the protection of steel, irrespective of cavitation. The bureau has had neoprene on trial on a radial gate of an irrigation project in the Southwest for 3 years. It is still in excellent condition. As mentioned previously, neoprene is also performing very well as a pipe lining in the Shadow Mountain tests.

Because of the cost of good surface preparation, an effective paint for rusted surfaces would be a desirable development. So far, however, bureau laboratory tests have failed to disclose a superior paint system for rusted surfaces. Red-lead in oil (TT-P-86a, Type I) has been as effective as any primer tested for such applications, but no paint system has performed as well over a rusted surface as over a clean surface. A year ago, field tests of various paints which were supposed to be suitable for rusted surfaces were started on steel stoplogs stored at Hungry Horse Dam. These tests are expected to be helpful in determining the economy of painting over rusted surfaces.

Two types of relatively new coating materials that warrant watching are the zinc-pigmented inorganic coatings and the epoxy resin coatings. The bu-

reau's first tests on the zinc product did not indicate it to have exceptional properties. Improvements have been made in the coating, however, and, as more recent applications indicate, there is reason to believe that this coating has promise. Bureau tests on epoxy resin paints have only recently commenced, but the characteristics noted so far are very favorable.

Summary and Conclusions

The following statements summarize bureau laboratory and field experiences with various protective coatings for steel water pipe. It should be understood that conclusions are predicated on the assumption that surfaces are properly cleaned, generally by blast cleaning, and that the coatings are properly applied and of good quality and adequate thicknesses.

1. Coal-tar enamel has shown itself to be an excellent product for lining steel water pipe, except where the lining will be exposed to temperatures of less than -20°F . Coal-tar enamel is also well suited for the exterior of buried steel pipe, provided the coating is adequately reinforced or shielded against soil stress.

2. Cement mortar is another effective lining material for steel water pipe, provided the lining will not be exposed to extended drying periods. Cement mortar also provides an excellent exterior coating that is unaffected by soil stress.

3. Properly formulated vinyl resin and phenolic-resin paints provide serviceable linings for steel water pipe and are not adversely affected either by low atmospheric temperatures or by drying out periods. Phenolic vehicles are also well suited for priming paint

and aluminum finish paint for the exterior of exposed steel water pipe.

4. Glass mat and asbestos felt are effective wrapping materials for coal tar-enamel coatings. Glass-mat reinforcement imparts added resistance against cracking of enamel in cold weather, and is preferred as the first wrapping in a multiple-coat system because it provides a smoother coating essentially free from vapor pockets. Glass mat-reinforced enamel is resistant to soil stress, but because cracking will extend to the embedded-glass reinforcement, thus reducing the effective enamel thickness, asbestos felt is preferred as an outer wrap where clay soils make up the backfill.

5. Vinyl and polyethylene plastic tapes will apparently provide effective exterior protection for straight pipe and welded joints. A prime coat is considered desirable to improve adhesion when applied in cold weather and to minimize possible rusting at tape overlaps. Glass-reinforced, coal tar-enamel tape also provides effective protection and is adaptable to wrapping fittings because it can be molded to fit closely and make a good seal over irregularities. The use of plastic fillers may be a solution to this problem in the case of plastic tapes. Double wrappings are indicated for either type of tape in highly corrosive soils or those inducing severe soil stress.

6. Brushed neoprene coatings appear to be well suited to the lining of steel water pipe and offer improved resistance to cavitation erosion. Zinc pigment, inorganic-vehicle coatings, and epoxy resin coatings are other materials showing promise for the protection of steel water pipe. So far, no paint system has been found that will

perform as effectively over a rusted surface as it will over a well cleaned surface.

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Electrical Inspection of Steel Pipe Coatings

S. Mark Davidson

A paper presented on Jun. 15, 1955, at the Annual Conference, Chicago, Ill., by S. Mark Davidson, Chief Engr., Thompson Pipe and Steel Co., Denver, Colo.

THIS discussion of electrical inspection of coatings will be confined to specified coal tar-enamel coatings (1). Paints included in the specifications will not be discussed, since their dielectric strength and film thickness are insufficient to permit electrical inspection.

Voids, foreign inclusions, bare spots, pinholes, and mars from handling are commonly called holidays in coatings on steel pipe. An apparatus to discover these holidays, or defects, in the coating is commonly called a holiday detector.

Coatings on steel pipe protect the pipe from corrosion by resisting penetration of moisture and by being electrically resistant to voltages generated in the soil in which the pipe is buried and to voltages of stray currents in the area of the pipe. Holidays in the coating, of course, spoil the effectiveness of the coating, and corrosive currents can attack the steel pipe at these points. Holidays, therefore, must be detected and repaired to be sure that steel-pipe coatings are completely effective.

Causes of Defects

Defects such as voids may occur in a coating because of incomplete coverage or because of physical damage which results from mishandling. Air enclosures and pinholes may be caused by excessive moisture at the time of

coating application or, occasionally, by mechanical application procedure. Pipe coating that has an asbestos wrap over the enamel may develop air pockets and pinholes in the enamel because the wrapper is not forced against the enamel sufficiently, because the wrapper is damp, or because the saturant in the wrapper is not compatible with the high-temperature enamel used in water works practice. Foreign particles in the coating are usually caused by lack of care in handling the coating. Care must be exercised to keep the enamel clean when it is cut into chunks of proper size for melting and while the cut enamel is being stored. Coke, caused by overheating or prolonged heating of the enamel, is another source of foreign-particle inclusion in the coating.

Most of these causes of holidays in the coating are controllable, but, because of the fallibility of the human element, some manner of quality control is necessary. Electrical inspection answers this need.

Theory

Electrical inspection of coating is not a method of testing the quality of the coating material. The electrical resistance of coal-tar enamel is far in excess of the resistance required to block the voltages encountered in service. The actual electrical resistance of an insulat-

ing material apparently has no direct connection with its dielectric strength (2). Air has a very high insulation resistance but not a very high dielectric strength. Coal tar enamel-coating has both high insulation resistance and high dielectric strength. The electrical holiday detector takes advantage of the high dielectric strength of coal-tar enamel in testing for continuity. The difference between the dielectric strength of the air in a holiday and the dielectric strength of the coal-tar enamel makes possible the use of an electrical holiday detector which applies a high electrical potential between an electrode and the steel pipe, with the coating acting as an insulator between the two. Where there is a void or holiday in the coating, because of the comparatively low dielectric strength of the air in the holiday, a spark is generated between the electrode and the pipe.

An electrical holiday detector cannot be relied upon as a method of determining thickness. There are so many uncontrollable factors, some of which affect the breakdown strength of the coating even more than does the thickness of the coating, that the application of a high electric potential will not reliably indicate coating thickness. Even the dielectric strength of coal-tar enamel per unit of thickness varies inversely in relation to the total applied thickness. Other factors affecting the breakdown strength of the coating are size and shape of the electrode used in applying the voltage, form and distribution of the field of electric stress in the coating material, frequency of the applied voltage, rate and duration of voltage application, fatigue with repeated voltage applications, temperature, and moisture content of the wrapping material. In fact,

a good coating of satisfactory thickness may be seriously damaged if voltage sufficient to approach breakdown level is applied in an effort to measure thickness.

Methods of Electrical Inspection

There are two general methods of electrical inspection in common use today. The first is the method used to determine whether or not a coating of satisfactory quality has been applied by the coating applicator. This inspection is usually performed at the coating plant as a quality control and also at the trench site for determining damage from handling and for inspecting field-applied coatings on field joints. In this method, an electrical voltage is applied of sufficient magnitude to spark across the air gap in a holiday. In its simplest form, this holiday detector includes a primary source of power, a secondary high-voltage output, an electrode to explore the coating, and a ground or return circuit to the pipe. This method of inspection can be used for either interior or exterior coating.

Because holidays are always possible, all steel-pipe coatings should be inspected electrically with a holiday detector. With good coating practice and diligent operation of the coating equipment, holidays on interior, centrifugally cast, coal tar-enamel linings can be practically eliminated. Holidays are most prevalent in the coatings of hand-daubed specials that cannot be machine coated. Since a holiday in an otherwise continuous coating acts as a focal point for corrosive attack, all coatings should be inspected and holidays repaired to the utmost extent practically possible.

A second method of electrical inspection of steel pipe coatings is the method

of testing the exterior coatings after the pipe is in service. It is sometimes desirable to know the coating condition after a period of use. One way of accomplishing this is by an over-the-ground potential-gradient survey with interrupted d-c applications.

This method utilizes the interruption of the protective current flow to the pipeline while the potential gradient is being measured. The potential gradient is observed between two nonpolarizing standard-reference electrodes. One electrode is placed in a fixed position and the other is positioned at regular intervals over the pipeline. The protective current flow to the pipeline is interrupted each time the moving electrode is positioned at regular intervals. The flow of current toward the flaw, or holiday, in the coating will result in a distinct change in the potential gradient.

Another way of discovering holidays in the exterior coating of buried steel pipe is the use of a 1,000-cycle per second signal and earphones (3). A signal generator or transmitter section of the instrument is connected between the pipeline under test and a ground connection, such as a ground rod or metal fence, approximately 100 ft from the pipeline. The output from the generator is a 1,000-cycle per second alternating current which flows through the earth between ground connection and line. Because of the fact that the coated pipeline will have minimum resistance to earth at locations of coating holidays, current density in the earth at these locations will be a maximum and will cause relatively high IR (current times resistance) voltage drops in the earth in the vicinity of the holiday.

The areas of high IR drops are located by using the receiver portion of the instrument, which is a sensitive audio amplifier. Two men wearing metal shoe cleats walk along over the pipe approximately 20 ft apart. One man carries the receiver and wears earphones which plug into the output of the receiver. The receiver input is connected to the shoe cleats of each man through suitable flexible leads. When a holiday is approached, the tone volume in the earphones increases and reaches a maximum when either man is directly over the holiday. A visual indication is also given by a meter in the receiver.

Electrical inspection of the coating may be performed at any time after the coating is applied until the pipe is laid in the trench, and, by the special equipment described above, after the pipe is backfilled and in service. In water works practice nearly all steel pipe is coated in a pipe-coating yard, because the centrifugal casting of the interior coating cannot be done satisfactorily along the trench site. Steel pipe, for service other than water, does not require interior coating when the material transported in the pipe is non-corrosive. This pipe is often coated on the exterior after the pipe is joined, either above or adjacent to the trench. Steel pipe for water service, however, is usually coated on the exterior in the same yard that applies the interior coating. It is generally convenient to inspect electrically the pipe coating in the yard where the coating is applied, because electric power is readily available and the pipe can be handled easily.

Because of this difference between coated steel pipe for water works use and coated steel pipe for use in transporting non-corrosive materials, such

as encountered in oil country use, methods and equipment for testing water pipe vary somewhat from the methods and equipment used to test oil country pipe.

Testing Equipment

The spark-generating unit of an above-the-ground holiday detector usually has output voltage which is either 60-cycle alternating voltage or impulse voltage. Even the impulse voltage, although originating from a d-c storage battery as a primary power source, is essentially an alternating voltage.

In pipe-coating yards, which are prevalent in the water works coating industry, a-c transformers are very convenient for use as spark generators because of the availability of reliable, steady, and economical 110-v or 220-v a-c power. An ordinary neon light transformer of proper ratio makes a very good a-c transformer for this purpose.

Most neon light transformers are constructed in such a manner that the short-circuit current is only $1\frac{1}{2}$ times the full-load current. The electrical code, under which these transformers are manufactured, limits the short-circuit current to this value as a safety precaution, and this fact also makes them safe for use as a holiday detector spark generator.

Neon light transformers are constructed with a short air-gap shunt in the magnetic circuit between the primary and secondary windings. When a short circuit occurs on the secondary high-voltage circuit, the magnetic flux in the core of the transformer encounters a high resistance caused by current flowing in the secondary coil. Because the air gap shunt has a lower resistance to the magnetic flux than is

encountered in the core when the secondary is short circuited, a large portion of the magnetic flux jumps the air gap, is shunted away from the secondary coil, and the short-circuit current is thereby limited.

This air gap shunt in the magnetic circuit gives the transformer poor voltage regulation characteristics: that is, the output voltage drops rapidly as the current increases. These transformers are available, however, with a range of output voltage and normal-rated current of 18-240 ma. Selection of a proper neon light transformer to provide correct voltage at the necessary current level is therefore not difficult. It is advisable, however, to select a transformer with an output voltage slightly higher than the desired test voltage, and to use a variable auto-transformer in the primary circuit which can be adjusted to bring the output voltage of the system to the desired value while actual testing is being done and the system is under full normal load. Because of variations in the load on the holiday detector, which will be described later, occasional checking and adjustment of the output voltage under load is necessary. The output voltage can be checked by proper high-range voltmeters or by a sphere gap with the proper space between spheres.

The neon light transformer can be housed in a box, preferably constructed of wood or other nonconducting material. This box can house an off-on switch, the variable auto-transformer, a light to indicate when the transformer is energized, and a signal to indicate a holiday. In the primary circuit, a relay that will trip when a holiday is contacted by the exploring electrode, causing the primary current to in-

crease, can be used to energize a red light, a bell, or any signaling device that is desired.

The center tap of the secondary coil of these transformers is usually grounded to the case housing the coils. This center ground should be eliminated.

Many sources of a-c power have one side grounded. A high potential then exists across the windings of the transformer, and the slight insulation of the coils will be punctured if the center ground of the secondary is not removed. The primary coil is connected to the a-c source of power through the variable auto-transformer and an off-on switch. One side of the secondary output is grounded to the steel body of the coated pipe with a properly insulated cable and a spring-loaded alligator clamp. The other side is connected to the exploring electrode by a properly insulated cable.

For the field testing of coatings, to discover damage from handling or damage caused in transit or to test field-applied coating at pipe joints, commercially manufactured holiday detectors are available which utilize d-c batteries as a source of power.

Usually these holiday detectors employ an impulse voltage spark generator. Since coatings can be damaged by continuously applied high voltage, as will be discussed later, these impulse generators ingeniously provide short-period high-voltage impulses on the order of 100- μ sec duration. These short-duration impulses are generated at a rate of approximately 30 per second, which is more than sufficient to cover the surface of the coating thoroughly as the exploring electrode is moved forward at a normal rate. During an hour of testing, the testing voltage is actually present for only a few

seconds. This fact reduces the power requirement, resulting in long battery life as well as reducing the tendency toward coating damage.

Ignition coils with a built-in vibrating interrupter, such as the Model-T Ford ignition coil, are not entirely satisfactory for use as a spark generator. The variation in the degree of contact which the points make at each closing, and the variation in adjustment of the spring which causes the points to open, affect the output voltage. The frequency of output voltage is highly variable and erratic and is generally too high. A good coating of specified thickness can be damaged under certain test conditions. Previously non-existent holidays have been "discovered" by this type of equipment in the field. Misunderstandings occur when apparent holidays are discovered in undamaged coating that has satisfactorily passed inspection with an adequate holiday detector in the coating yard.

The exploring electrodes connected to the output of the spark generator can take many forms. For testing the interior coating, a ring of wire brushes fastened to a frame of light structural tubing supported on rubber-covered wheels, as shown in Fig. 1, is very useful. This ring of brushes is slightly larger in outside diameter than the inside diameter of the pipe to be tested so that each individual wire in the brush is bent slightly when in use and a positive contact with the coating is maintained. This assembly is pulled through the coated pipe by means of a small rope and the entire circumference of the pipe is inspected at one time. For large-diameter pipe, where such a full-circumference frame is impractical, a wand can be made by attaching wire brushes to a straight frame (see Fig.

2). As the brushes move over the coating each sweep tests a strip of coating as wide as the wand is long.

The exterior coating is most easily inspected by using an electrode made of a coil spring, shown in Fig. 3. The pitch of the spring should be such that very little gap is present between the individual coils. Such a spring is wrapped completely around the outside of the pipe, with the ends fastened together. There should be a slight tension in the spring to maintain positive

wheels is always in contact with the coil spring, it is properly energized.

Test Voltage

Fear of actually puncturing and damaging a coating that would otherwise be acceptable should not discourage use of an electric-spark holiday detector. With intelligent operation and suitable equipment, the voltages required to jump an air gap will not damage the coating.

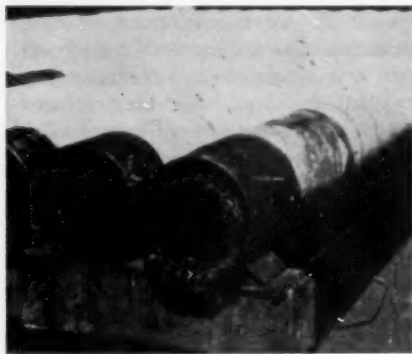


Fig. 1. Wire-Brush Electrodes for Interior Coatings

A ring of wire brushes fastened to a circular frame is used as the exploring electrode for pipe of small diameter.

contact with the coating. This coil-spring electrode can be pushed along the length of the pipe section being tested by a four-wheel skate with a wooden frame and handle. The skate is constructed like a child's roller skate with the coil-spring electrode between the front and rear wheels. The output of the spark generator is connected to the wheels by a properly insulated conductor. Since one or more of the

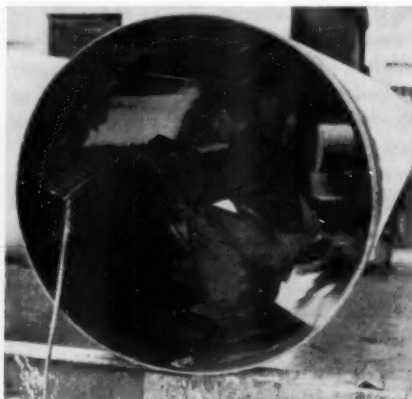


Fig. 2. Exploring Electrodes for Pipe of Large Diameter

Brushes are attached to a straight frame and the unit is moved over the coating.

The minimum voltage that can be used successfully, with complete assurance that no holidays will be missed, is the voltage that will jump an air gap equal to the greatest distance between the exploring electrode and the pipe. The AWWA specifications call for coal-tar enamel to be $\frac{3}{32} \pm \frac{1}{32}$ in. thick (1). This could be a maximum of $\frac{1}{8}$ -in. thickness. A wrapper of nominal 15-lb asbestos felt is approximately

0.02 in. thick. If allowance is made for double thickness of laps this could amount to 0.04 in., or nearly $\frac{3}{64}$ in. added to the coal-tar thickness, making a maximum coating thickness of $\frac{1}{8}$ in. It is reasonable to assume that $\frac{1}{4}$ in. is the maximum air gap that would have to be jumped. This gives $\frac{5}{64}$ in. in addition to the maximum coating thickness to allow for the possibility that the holiday may have a slanting, rather than a straight, course through the coating or that, at this point, the electrode may not be absolutely tight against the coating.

The exact voltage needed to spark over an air gap of any given length is dependent upon many variables such as frequency, air pressure, humidity, temperature, electrode configuration, and wet or dry surfaces. At Denver, which is a mile above sea level, only 83 per cent of the sea level voltage is required to spark over a given air gap, all other conditions remaining the same. If surfaces are relatively dry, as they should be, and sea level voltage requirements are taken into consideration, all other variables except electrode configuration and frequency are relatively unimportant.

Between needle points, 10,000 v at 60 cycles per second will spark over 0.468 in. Between a point and a ground plane the spark-over distance is a little greater (2). Although the voltage required to spark over a gap is not exactly proportional to the length of the gap, a $\frac{1}{4}$ -in. air gap could be jumped by approximately 5,000 v between needles or between a needle and a ground plane. Between two 12.5-cm diameter spheres, about 14,000 v will spark over $\frac{1}{4}$ in. (2). All of these voltage values are crest-of-voltage-wave values, which should not be con-

fused with root-mean-square voltages common in electric-power calculations. Insulation-breakdown voltages and air-gap lengths depend upon maximum voltages at wave crest. The maximum voltage of a 60-cycle alternating-voltage sine wave is 1.42 times as great as the root-mean-square value.

Because the electrode of a holiday detector consists of wires approximating a needle shape, and because the



Fig. 3. Exploring Electrodes for Exterior Coatings

A coil spring is wrapped around the exterior of the pipe, with the ends fastened together. By means of a wooden skate the spring is pushed along the length of the pipe section.

pipe is a ground plane, the spark-over voltage for a $\frac{1}{4}$ -in. air gap would be much nearer the voltage of a needle-and-ground-plane spark-over than for the voltage of sphere-to-sphere spark-over. A potential of 12,000 crest volts of 60-cycle frequency at the electrode can be relied upon to disclose holidays in specified coatings. A transformer with a ratio of eighty to one, when used on a 110-v power source, will produce 8,800 root-mean-square (R.M.S.) volts,

or about 12,500 crest volts, and should be quite adequate.

Slightly higher voltages of the impulse type having steep wave fronts are required. The continuously applied (60 cycle or d-c) spark-over voltage is the lowest voltage at which spark-over can take place. For this reason, impulse-type holiday detectors operating from batteries usually have a 14,000-v output. Ground connections for

sary only for coatings of greater thickness than called for by AWWA specifications (1).

The maximum test voltage which should not be exceeded is, of course, the voltage that will cause breakdown of the coating. One coating manufacturer tested the dielectric strengths of specified coal-tar enamel in various thicknesses with the results given in Table 1. The voltmeter used in the test registered the root-mean-square voltages given and the crest voltages were calculated. It is interesting to note the variation in breakdown voltage per mil of thickness for various coating thicknesses.

Nearly 28,000 crest volts were required to produce breakdown for $\frac{2}{3}$ in., or approximately 60 mils, of enamel, the minimum thickness meeting AWWA specifications. It is apparent that the recommended 12,000-crest volt, 60-cycle alternating voltage, or the 14,000-v impulse voltage is safe to use. There is, however, no justification for exceeding these recommended voltages, even though the coating might stand it.

Higher coating-breakdown voltages are encountered when impulse voltages of short duration and steep wave fronts are employed. Just as higher voltages of this nature are required to spark over an air gap, so are higher voltages required to break down the coating. This increase in voltage required for breakdown is even more pronounced with solid insulators than with air gaps (5).

The breakdown voltages shown in Table 1 were obtained by starting with a low voltage and increasing at the rate of 1 kv per second until breakdown occurred. The maximum time required in any test was 27.4 sec. A much

TABLE 1
Breakdown Voltages for Coatings of Various Thicknesses

Coating Thickness mils	Breakdown Voltage		Breakdown Voltage per mil Thickness R.M.S. volts
	Root-Mean-Square kilovolts	Crest volts	
10	12.6	17,900	1,260
28	17.1	24,300	607
50	18.3	26,000	366
55	19.1	27,100	349
60	19.7	28,000	337
70	20.5	29,100	293
80	21.6	30,700	269
98	22.5	32,000	230
115	23.0	32,700	200
129	24.0	34,100	181
149	25.0	35,500	167
177	26.1	37,100	147
200	26.7	37,900	135
253	27.4	38,900	108

this type of detector used in the field on continuous pipelines are usually either dragging-wire or -chain, or a condenser plate dragged along the coating behind the detector, and are subject to variable influences such as moisture or contact with coating. A slightly higher voltage is a factor of safety under these conditions.

Although voltages considerably higher than recommended voltages have been reported (4), they are neces-

lower voltage applied for 4 or 5 min would have caused breakdown. The electrode of a holiday detector must be kept moving and must not be allowed to remain over one point on the coating while the equipment is turned on, because lingering in one spot can cause coating breakdowns with otherwise safe voltages. The slight partial breakdown of the coating with each testing is also accumulative, so it is imperative that retesting of the coating be held to an absolute minimum. In actual tests of insulating materials, no puncture was observed for eight repetitions of the applied voltage. On the ninth application puncture occurred (2).

Test Amperage

The test amperage is dependent upon the test voltage and the impedance of the load circuit. The impedance of the load on a holiday detector is a very complicated and variable electric circuit which depends on such factors as pipe diameter, whether or not the coating has a felt wrapper included, moisture content of wrapper, and length and condition of connecting leads. The amperage used in testing is not a value that can be arbitrarily determined. It is impossible to specify how many milliamperes shall be used in testing. The holiday detector has no way of controlling the maximum value of current which is to be supplied as is the case with a welding generator. The current which flows will follow natural electric laws.

The current rating of neon light transformers is the normal full-load operating current for that equipment. This rating must match or exceed the load demand. As the current demanded by the load circuit approaches

1.25 times this normal current, the voltage output of the transformer approaches zero, thereby limiting the maximum current. Transformers with 18-ma ratings have been found to be generally satisfactory.

When an exploring electrode is placed on a coated pipe, a simple electrical condenser is formed with the electrode acting as one plate, the coating as the dielectric, and the pipe as the other plate. Leakage resistance acts in parallel with this condenser and other resistances act in series with it. When the test voltage is applied, a condenser-charging current, as well as leakage currents, must be supplied by the holiday detector. Under certain conditions the condenser-charging currents represent a high enough proportion of the load that a voltage output increase can be detected when the electrode is energized, because the leading current charging the condenser supplies the magnetizing current for the transformer and its voltage output increases.

Under actual testing conditions on a 42-in. diameter pipe with coal-tar enamel and 15-lb felt wrapper, a transformer with 15,000 root-mean-square open-circuit volts produced 16,500 root-mean-square volts when the probing electrode was energized. On the same pipe, with spun interior coal tar-enamel lining, no voltage change occurred when the interior probing electrode was energized. This testing was performed under cover with dry pipe, dry soil underfoot, and short conductors to the electrode and ground connection.

Under other test conditions with damp soil, long conductors, damp felt, and smaller-size pipe, leakage currents

might have constituted a major portion of the load current supplied by the holiday detector and a voltage drop in the output of the transformer would have resulted. An occasional check of the voltage used under full-load conditions, as previously recommended, is desirable because of these variable conditions and the relatively poor voltage regulation of a neon light transformer.

Safety Precautions

The short-circuit current of a holiday detector must be limited in some manner to protect personnel from dangerous shock. An operator cannot let go of an exploring electrode supplied by a neon light transformer with a 12,000-v and 35-ma rating. The normal-current rating should be less than this value as a safety precaution.

Care should be exercised by the operators to avoid contact with the pipe, with exposed connections, or with the exploring electrode. Rubber gloves are helpful in avoiding accidental contact

with hot points. Damp wires, damp coating, damp soil, and wet feet increase the danger of accidental shock. Inspection should be discontinued under abnormally wet conditions.

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Design of Steel Pipe With Cement Coating and Lining

E. Shaw Cole

A paper presented on Jun. 15, 1955, at the Annual Conference, Chicago, Ill., by E. Shaw Cole, Vice-Pres. and Chief Engr., The Pitometer Associates, New York, N.Y.

THE excellent protection against corrosion that is provided by cement is well known. The neutralizing effect of the cement and the healing of cracks in the presence of moisture are factors of great importance in pipelines. Other methods of protection have merit, but the author's opinion, based on considerable first-hand experience in the water works field, is that cement is the best practical protection available today.

The pipe discussed in this paper is steel pipe with diameters of 30 in. or larger, which is protected by a cement coating and cement lining applied in accordance with standard specifications (1). This pipe will be referred to as "coated pipe."

There is much published information on coatings and linings but little on the subject of determining the proper thickness of the steel to be used, particularly when a cement coating or lining is involved. The entire subject of plate thickness is omitted from the AWWA specifications for steel water pipe larger than 30 in. in diameter (2). Rules of thumb are available, of course, and it is easy to add safety factors, but this is not a scientific approach and does not provide a pipe that is competitive with other types in cost and quality.

Pipe Thickness

The major considerations in determining the thickness of a pipe are the resistance to bursting pressure, resistance to collapse, and resistance to corrosion. Although much could be written on each subject and the variables involved, it will be assumed that no allowance should be made for corrosion and that the thickness of a pipe is to be determined for the following: steel pipe, in 16-ft lengths, with 60-in. ID after lining with $\frac{1}{2}$ in. of cement mortar, and with a $\frac{3}{4}$ -in. thick cement mortar coating reinforced by a 2 in. by 4 in. No. 13 gage-crimped wire mesh. The maximum internal pressure, including allowance for water hammer, is 136.5 psi, and the yield point of steel is 27,000 psi.

Bursting Pressures

The so-called hoop tension, or Barlow, formula commonly used to determine the thickness of steel pipe is:

$$t = \frac{PD}{2S}$$

where t is the thickness of steel pipe, P is the internal pressure in pounds per square inch, D is the diameter in inches, and S is the allowable working stress in pounds per square inch (usu-

ally taken as 50 per cent of the yield point). Substituting the above figures in the formula, the result is

$$t = \frac{136.5 \times 60}{2 \times 13,500} = 0.303 \text{ in.}$$

Because steel plate for water pipe in the United States is usually specified to the nearest $\frac{1}{16}$ in., a plate thickness of $\frac{5}{16}$ in. is indicated, which has a decimal equivalent of 0.312 in., thus adding 0.009 in. of steel to the theoretical amount of steel required. If the $\frac{5}{16}$ -in. thickness is substituted in the formula,

The total deformation equals the pipe circumference multiplied by the factor e . (The circumference for a diameter of 61.16-in. diameter pipe is 192.1 in.) Substituting in the equations, the unit elongation is

$$e = \frac{13,100}{30,000,000} = 0.000437 \text{ in./in.}$$

and the total elongation is

$$e \times 192.1 = 0.084 \text{ in.}$$

Total elongations for different stresses, determined according to the same formula, are given in Table 1.

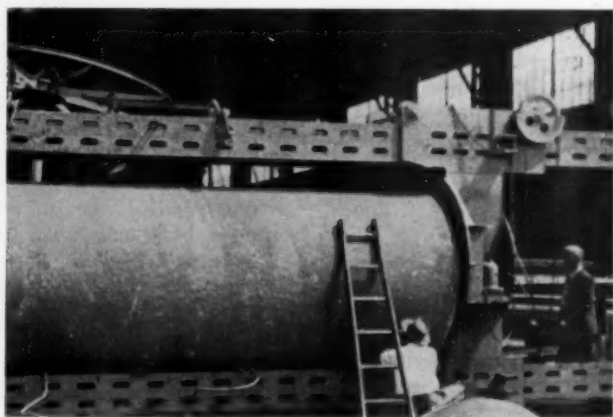


Fig. 1. Specimen Under Hydrostatic Test

Because steel pipe is not rigid, the cracks which develop are a natural result of internal pressures.

the working stress S is 13,100 psi instead of the 13,500 psi used above.

When a pipe is subjected to internal pressure, its circumference increases according to the basic formula:

$$e = \frac{S}{E}$$

where e is the unit elongation, S is the unit stress, and E is the modulus of elasticity (30,000,000 for steel).

The purpose of Table 1 is to show that steel pipe must deform when subjected to an internal pressure, the amount of deformation being directly proportional to the value used for unit stress. In the past, some specifications have used a value of 12,500 psi for the unit stress, but it should be noted that the use of this figure would decrease the total elongation from 0.086 in. to 0.080 in., a total of 0.006 in., or only 7 per cent.

Total elongation, however, is significant because it explains the cracks that develop when the pipe is subjected to working pressures. From the above figures it is evident that cracks must develop in this kind of pipe and, because this pipe is not rigid, are a natural result of internal pressure. Slight differences in the total elongation caused by changes in the allowable stress should not make an appreciable difference in the size and number of

size of crack will not be exceeded. A search of the published literature shows only one reference to a maximum crack size, and this is with regard to concrete culverts that have no steel cylinder. Tests witnessed by the author have shown that for a coating made according to the AWWA specifications (1), cracks are V shaped, and apparently disappear at the wire mesh. Inspection of a cutout section showed that below the wire mesh the steel plate was

TABLE 1

Total Elongations for Various Stresses

Unit Stress psi	Elongation in./in.
12,500	0.080
13,100	0.084
13,500	0.086
15,000	0.096

cracks, for there appears to be a large factor of safety when using 50 per cent of the yield point as the allowable stress. Tests (see Fig. 1) showed that, when this pipe was subjected to the design pressure of 136.5 psi, three small cracks appeared in the coating near the spring line.

When the pressure was increased to 172 psi—an increase of 25 per cent—the number of cracks also increased. Data are given in Table 2.

When the pressure was released, width of all the cracks decreased to 0.001–0.003 in. Cracks obviously developed in the lining also, but, because they were small, and because cement will heal in the presence of clear water, they have no significance.

If the pipe is to be semi-rigid and if there is to be any appreciable elongation of the circumference, cracks are inevitable. Once this is clearly understood, it becomes essential to have some basis for evaluating the effect of cracks in this type of pipe so that a maximum

TABLE 2

Increase in Number of Cracks With Change in Internal Pressure

No. of Cracks	Width in.	Length ft.
Internal Pressure—136.5 psi		
1	0.006	5
1	0.003	13
1	0.003	2
Internal Pressure—172 psi		
1	0.006	5
1	0.012	13
1	0.008	2
1	0.005	6
2	0.005	3
3	0.004	3
1	0.004	12

completely covered by uncracked cement mortar $\frac{1}{4}$ in. thick. This would indicate that, in all probability, the steel pipe was adequately protected against external corrosion.

One designer's opinion, based on only a few tests, is obviously insufficient evidence. There is a need for a series of scientifically conducted tests that will be sufficiently extensive to enable the Association to publish specifications and standards that can be used in the design of this type of pipe. If that were done, the designer would no longer be faced with a dilemma.

The problem is not just a matter of increasing the thickness of the steel plate to prevent cracks, for even if the thickness were arbitrarily increased by $\frac{1}{16}$ in. to allow for corrosion, as advocated by the Underwriter's Laboratory (3), cracks must develop. But, if cracks destroy the effectiveness of a cement coating in preventing corrosion, steel pipe should not be used without prohibitively expensive safety

factors. Conversely, if cracks are not harmful, no provision need be made for corrosion.

On the basis of the information presently available from various tests, it is believed that a crack 0.030 in. in width at the surface is permissible, providing its width decreases toward the wall of the pipe and becomes invisible to the naked eye beneath the wire mesh.

Load-carrying Capacity

Studies of the load-carrying capacities of bare steel pipe and cement mortar-lined and -coated steel pipe, based on published information and theoretical considerations, may be summarized in general.

The cement-mortar lining and coating strengthens the steel pipe against collapse. Tests of this characteristic (4) showed an increase of strength of over 600 per cent. Other studies have shown that the pipe wall thickness required for bare pipe, as a protection against collapse, has sometimes been reduced $\frac{1}{8}$ in. when gunite coating was used (5).

H. L. White (6) suggests that the coated pipe be considered as semirigid. This conclusion is also reached by considering the Marston theory for determining the magnitude of the loads to which underground conduits are subjected. The Marston theory is based on the following assumptions:

1. In relatively flexible pipes, the stiffness of the sidefills may approach that of the conduit, and the load on the conduit will be reduced by the amount the sidefills are capable of carrying.

2. In rigid pipes, the sidefills may be relatively compressible, and the pipe itself will carry practically all the load. The Marston formulas for determining the fill loads on flexible and rigid pipes are, respectively:

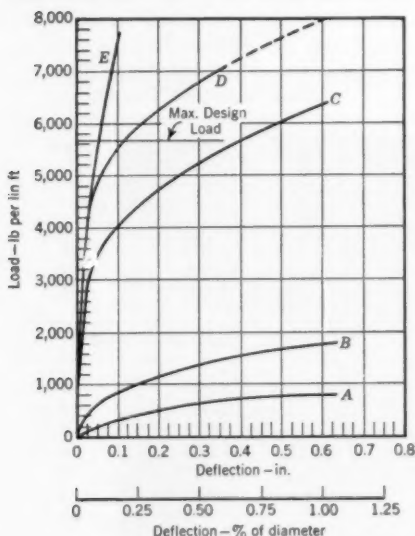


Fig. 2. Comparison of Tests on Pipe of $\frac{1}{8}$ -in. Steel Plate With $\frac{1}{2}$ -in. Cement Lining

Curves A and B represent Minnesota bearing tests on (A) bare steel pipe, and (B) steel pipe with 1-in. cement coating. The other three curves represent buried-pipe tests on (C) steel pipe with $\frac{3}{4}$ -in. cement coating, buried in trench with 4-ft cover, with backfill compacted by 25-ton load, (D) steel pipe with $\frac{3}{4}$ -in. cement coating, buried in trench with 4-ft. cover, with backfill compacted by 25-ton load, and (E) composite pipe, after backfill compaction. The surface load factor for each pipe test was 0.0652, and the maximum design load was 5,680 lb per linear foot.

$$W_F = C_d \times j \times b \times D$$

$$W_R = C_d \times j \times b^2$$

where j is the unit weight of filling materials, C_d is the coefficient depending on the soil characteristics, b is the width of trench, D is the outside diameter of pipe, W_F is the fill load for flexible pipe, and W_R is the fill load for rigid pipe. Therefore,

$$\frac{W_R}{W_F} = \frac{b}{D}$$

For the conditions assumed in this paper ($D = 5$ ft and $b = 7$ ft) the fill load on the rigid pipe would be 40 per cent greater than on the flexible pipe. Even though it is not accurate to consider the coated pipe as completely rigid, it seems reasonable to assume that the coated pipe would be subjected to a load somewhat higher than the bare pipe. This leads to the assumption that ground surface loads, such as truck loads, transmitted through the soil to the underground pipe, are only partially absorbed by flexible pipe, but almost totally absorbed by rigid pipe.

Several formulas for determining the load-carrying capacity of flexible and rigid pipes have been developed. Those formulas cannot be used on the semi-rigid coated pipe, however, because, in coated pipe, deflections can occur before appreciable stresses develop on the side walls of the pipe, thus causing the separation of the coating from the steel wall, and because the ring theory (elastic theory of flexure) cannot be applied on account of the stiffness of the coated pipe. It seems, therefore, that a formula for designing coated pipe must be derived empirically and should be based on tests made under actual conditions to determine the relationship between loading and deflection and the effect of deflection on the coating and lining.

Published information for bare steel pipe, for example, mentions 2 per cent as a reasonable deflection for design, but one reference states that many large pipes have operated satisfactorily with deflections of 5 per cent or more. Obviously, deflections such as these would cause large cracks in a cement coating. From tests previously reported by White (6), a deflection of 1 per cent might be considered a maximum for 30-in. or 36-in. pipes, but the tests referred to were made on a different type of pipe than the one being considered here, and therefore are not conclusive or complete.

Test Program

In order to determine the performance of a 60-in. pipe under external loads, tests were made by two independent manufacturers of this size of pipe. Neither test gave complete information for design purposes, but, when combined, the tests provided a valuable relationship between tests made by the Minnesota bearing method and those made under trench conditions. With the permission of the manufacturers this information is being released for the first time.

One series of tests was made at Bogata, N.J., by the Centrline Corporation, New York. The other series of tests, referred to, was made by the American Pipe and Construction Company, South Gate, Calif. Both tests were made during the summer of 1953. The pipe tested by both companies was made in accordance with the AWWA specifications. The steel plate used in all tests was $\frac{5}{16}$ -in. thick. The coating used by Centrline was nominally 1 in. thick (actually $1\frac{1}{4}$ in.) and the coating used by American was $\frac{3}{4}$ in. thick.

For tests made by Centrline the Minnesota bearing method was used.

This is similar to the three-edge bearing method, except that the pipe is supported by a bed of sand. According to Spangler (7) a load factor of 1.1 is required to convert Minnesota bearing tests to three-edge bearing tests. The deflections for various loads per foot for bare steel plate $\frac{5}{16}$ in. thick, and for cement-coated steel pipe having $\frac{5}{16}$ -in. steel plate are shown in Fig. 2 as Curves *A* and *B*.

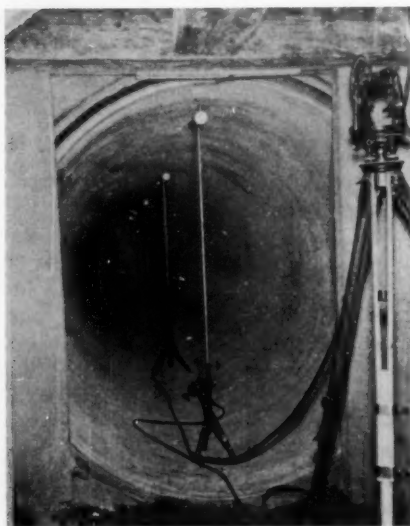


Fig. 3. Instrumentation for Buried-Pipe Tests

The dial indicators inside the buried pipe were read from an inspection pit at one end of the test section.

For the tests made by American Pipe and Construction Company, the pipe was buried in a trench and the backfill compacted by mechanical tampers. The dial indicators were read from an open inspection pit, shown in Fig. 3, at one end of the section under test. The cement-coated $\frac{5}{16}$ -in. steel pipe was used as a control for comparison with composite bar-wrapped steel

pipe manufactured by the same company. The deflection of cement-coated steel pipe, resulting from various loads applied to a platform placed on the ground directly over the pipe (see Fig. 4), are shown in curve *C*, Fig. 2. The load per foot was computed according to the Boussenesq theory for the distribution of stress within a semi-infinite elastic body (8). A conservative surface-load factor (ϕ_{avg}) of 0.0652 was used to convert the total surface load to a load per foot, although a factor of $\phi_{max} = 0.0804$ would probably comply better with the test conditions.

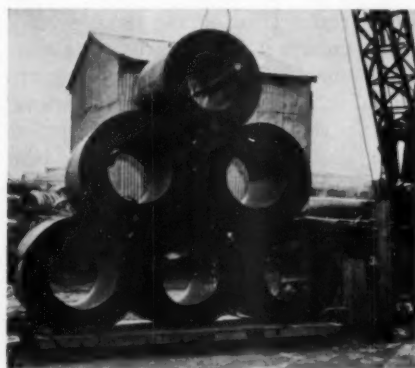


Fig. 4. Applying Load to Buried Pipe
Various loads were applied to a platform placed on the ground directly over the pipe.

The tests were later repeated, and, because of the compaction that resulted from application of the total load of 25 tons, the load per foot for a given deflection was considerably higher. These results are shown as Curve *D* in Fig. 2. Table 3 gives the data used to plot curves *B*, *C*, and *D*.

The resistance of the composite bar-wrapped steel pipe is shown as Curve *E*. The design load indicated on the chart is 5,680 lb per linear foot, and includes the maximum allowance for

dead and live loads in accordance with AWWA approved practice.

The information shown by these curves is summarized in Table 4 for deflection of only 0.5 per cent, which is about the maximum obtained for *D*.

Some of the significant information shown by the curves and tables can be summarized as follows:

1. The coating and lining of the $\frac{5}{16}$ -in. steel plate increased the resistance to crushing, when tested by the Minnesota bearing method, at a 0.5

3. The load factors for converting the results obtained by the Minnesota bearing method are 3.9 for the mechanically tamped backfill and 5.0 for the well compacted backfill at a deflection of 0.5 per cent.

Conclusions

Tests and studies made in connection with the design of a long 60-in. supply main led to the following conclusions:

1. Thickness of the steel plate should be computed by the Barlow formula using a steel stress of 13,500 psi, which is equal to one-half the yield point of the steel specified. This gives a thickness of $\frac{5}{16}$ in. for the maximum internal pressure of 136.5 psi.

2. A $\frac{1}{2}$ -in. thick cement-mortar lining and a $\frac{3}{4}$ -in. thick cement-mortar coating, reinforced with 2-in. by 4-in. No. 13 gage crimped-wire mesh, all applied according to AWWA standard specifications C205, was considered satisfactory corrosion protection for the steel plate. Such a pipe was semi-rigid, and appreciable deformation was a natural result of internal pressures and external loads.

3. The coated and lined steel pipe thus made developed two cracks 0.003 in. thick and one crack 0.006 in. thick in the coating when subjected to the maximum design hydrostatic pressure of 136.5 psi. When the pressure was increased to 172 psi (125 per cent of the designed head) there were ten cracks in the coating that ranged from 0.004 in. to 0.012 in. in thickness.

4. When the same pipe, installed in a trench with a well compacted backfill, giving a cover of 4 ft over the top of the pipe to simulate operating conditions, was subjected to loads, it was found that the maximum design load of 5,680 lb per foot caused a deflection of 0.12 in., or 0.2 per cent of the diameter.

TABLE 3

Load-carrying Capacity of Steel Pipe Coated and Lined With Cement

Total Load lb per ft	Deflection of Pipe					
	Curve B		Curve C		Curve D	
	In.	%	In.	%	In.	%
1,000	0.145	0.24				
1,350	0.30	0.50				
1,750	0.60	1.00				
3,000			0.025	0.04	0.015	0.02
4,000			0.10	0.17	0.025	0.04
5,000			0.25	0.42	0.055	0.09
5,680			0.40	0.68	0.11	0.18
6,000			0.49	0.82	0.15	0.25
7,000					0.35	0.58

per cent deflection, from 600 lb per linear foot to 1,350 lb per linear foot, or an increase of 125 per cent.

2. When tested in a well compacted trench, the coated and lined pipe had a resistance of 6,800 lb per linear foot for the same deflection of 0.5 per cent. This is an increase of 5,450 lb per foot, or approximately 400 per cent, caused by the effect of the trench. Theoretical considerations based on the Marston formula and reports for rigid pipe would result in increasing the results obtained by the Minnesota bearing method by only 156 per cent.

TABLE 4
Loads Required to Produce Deflection of 0.5 Per Cent in 60-in. Steel Pipe

Curve	Type of Pipe	Test Condition	Load—lb/ft
A	Bare steel pipe	Minnesota bearing	600
B	Cement coated and lined	Minnesota bearing	1,350
C	Cement coated and lined	Buried in trench, backfill mechanically tamped	5,230
D	Cement coated and lined	Buried in trench, backfill compacted by 25-ton load	6,800
E	Bar-wrapped steel pipe		>8,000

5. Tests made by the Minnesota bearing method indicated that a deflection of 1 per cent would not result in serious cracking of the coating or lining. When the pipe was installed in a well compacted trench, a deflection of 1 per cent would be developed by a load of 8,000 lb per foot, which is approximately 1.4 times the maximum design load.

6. Other types of steel and concrete pipe, such as the composite bar-wrapped pipe, may have greater resistance to crushing, as shown in Fig. 1. This greater strength is not required for the assumed conditions, and there does not appear to be any rational basis for evaluating the differences in strength.

7. For a given set of conditions, steel pipe, coated and lined in accordance with AWWA specifications, should give satisfactory service if designed according to the standards presented.

8. Further study is urged so that the AWWA may prepare and publish standards that can be used in the design of this type of pipe.

Acknowledgments

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Electrical Reliability in Water Plants

E. O. Potthoff and N. L. Hadley

A paper presented on Jun. 15, 1955, at the Annual Conference, Chicago, Ill., by E. O. Potthoff, Water and Sewage Application Engr., and N. L. Hadley, Power Systems Engr., both of General Electric Co., Schenectady, N.Y.

A VAST number of potential mechanical and electrical failures exist in the water plant, and some failures are bound to occur. It is the job of plant engineers, plant superintendents, and consulting engineers, therefore, to anticipate the sources of at least the major failures and to build some relief measures into the electrical system and operating procedures.

The desire to reduce the number of plant failures to a minimum has led engineers to study methods for improving the "reliability" of the electrical system and its components. Reliability may be defined as the expected or realized ability of a system, process, or machine to operate without failure, and its importance in the plant is shown clearly by the possible penalties which result from a power failure. Certain machines in the plant can become completely jammed by the debris or sediment resulting from failures, and time and money must be spent in cleanup. The loss of pressure in the distribution or transmission main may introduce a potential health hazard or endanger fire protection, thereby jeopardizing relations with consumers. Excessive flows or backflows in these mains, resulting from complete pumping failure, may loosen deposits and create other consumer complaints.

It is essential that all those groups who can contribute to the sound planning and final successful performance of a plant understand the planned objectives and sense the importance of a well coordinated relationship between the various parts of the overall electrical system. These groups are the power companies, the consulting engineers, the equipment suppliers, and those individuals in the water department who are officially responsible for planning and operating the plant.

This paper will attempt to approach the problems of an electrical system from a broad and fundamental standpoint rather than from the detailed, technical viewpoint of the electrical engineer. Because the failure of a single motor or its supply cable is not usually serious, a spare machine being generally provided to replace the one that has failed, this discussion will treat the more serious power interruptions by which all process machinery of one type or another, such as all wash water pumps or all finished-water pumps, is affected. An electric utility will be considered as the only power source, because the majority of plants purchase all their power from electric utilities.

Although the subject of reliability will be approached statistically and by a study of incidence and probability of

failure, there is no such thing as an empirical or mathematical solution of the whole problem. The statistics included in this paper, therefore, are to be used only as a starting point for sound electrical planning, with allowances made for the individual characteristics of the system concerned.

In approaching the reliability problem there are three logical steps:

1. Determine as nearly as possible the allowable power-outage time for each operation or process in the plant.

2. Investigate the probable maximum outage time which might occur in the electric utility service to the plant. This maximum expected interruption should be less than any of the allowable outage times for plant operations or processes. If it is not, a more reliable utility service should be obtained.

3. Design the plant power system to provide a reliability which is adequate for the demands of each process or operation in the plant.

Allowable Power-Outage Time

The degree of reliability demanded by the electrical system and its components varies considerably from plant to plant and from operation to operation within a plant. It is difficult, therefore, to generalize or make blanket recommendations. Typical allowable outage times for various operations should be compiled, however, so that the problem can be narrowed down to provide a starting point for its solution. Extreme care must be exercised in using these general data because of possible deviations in special situations.

Table 1 shows the approximate allowable power-outage times for various operations within the water plant. These data reflect the thought and experience of plant managers and operat-

ing personnel, whose agreement was reasonably good. On a few points—the allowable outage time for sedimentation, for instance—considerable variation is possible because of the wide range of turbidity in the raw water. The times shown for the screens and both the raw-water pumps and the distribution pumps show moderate variations. These variations do not indicate differences of opinion, however, as much as they indicate different conditions.

Mechanically cleaned bar screens and traveling fine screens cause a special problem because they soon plug up and restrict the flow of water to the plant. The bar screen can be expected to operate for as long as a day without cleaning and the fine screen will require cleaning even sooner. These time-lengths will be subject to variation because of changes in amounts of incoming drift and fine debris. Relatively few stations are equipped with bypasses for handling emergencies caused by failures.

The criterion for raw-water pumps in Table 1 was the adequacy of raw-water storage immediately preceding the treatment plant. This storage reservoir often serves as a presedimentation basin. A general time is difficult to estimate because the amounts of storage vary radically from plant to plant.

Most plants appear to have an allowable outage time of approximately 24 hr for the scrapers of the primary-sedimentation tanks. This will vary considerably, of course, if there are appreciable changes in the incoming turbidity. A failure of power to all scraper mechanisms opens the possibility of letting the scrapers become mired in by the sludge. To restore operations it would be necessary to drain and flush

the basins one at a time. In those plants in which the only means for removing the sludge is by flushing, the limiting criteria used for Table 1 are the amount of flushing water stored under head and an allowable limit of sludge-cake buildup. Since the basin is normally drained for cleaning, a power failure in this process is generally of little consequence.

The remarks covering the primary-sedimentation process are generally applicable to the secondary-sedimentation process, except that the latter process will probably have an appreciably longer allowable power-outage time. A time in excess of 24 hr is usually satisfactory for the mechanically cleaned basins.

The chemical feeders for fluoride, soda ash for softening, and anti-corrosive additives are considered non-critical in most plants. Other chemical feeders which may be considered critical are preliminary lime, soda ash for pH control, filter alum, ferrous sulfate, ferric chloride, ferric sulfate, feeders for final chlorination, and activated-carbon feeders. Loss of feeders for floc-forming chemicals will result in poor filter runs, a result which is both costly and dangerous because it may seriously reduce plant capacity. Short outage times of about $\frac{1}{2}$ hr are generally desired.

No electric power is needed for most chlorinating apparatus. Solution chlorinators that require evaporators or auxiliary pumps for the supply of injector water may have short allowable power-outage times, however, and may be critical items.

One facility which works in conjunction with the chemical feeder and shares its functional importance is the plant-process water system. If the plant process water requires auxiliary

pumps, the importance of these pumps will be decided finally by the amount of process-water storage and the allowable outage time of the chemical feeders.

The loss of power to power-driven mixing equipment will reduce the efficiency of floc production which results in short filter runs and reduced plant output. From the results of the survey it would appear that flash mixers may be inoperative indefinitely, but the flocculators may be out of service no longer than 24 hr.

Outage times for wash-water pumps are determined by the amount of wash-water storage and the water demands on this storage. These demands generally vary with the season, thus making the planned outage times variable. If the system is equipped with a storage tank supplied by wash-water pumps, the allowable outage time may be approximately a day. If the tank is interconnected with the distribution system, the time period may be indefinite, as is true if no storage tank is involved and the wash water is obtained directly from the distribution mains.

The last process to be considered is that of pumps for distribution to the mains. Considerable variation in time is found because of variations in system storage. The penalties of prolonged failure are invariably serious, as indicated in the table. This allowable outage time may vary from practically zero minutes to a number of weeks. This phase of operation is probably the best known, because the problem seems to be generally understood and considerable thought has been given to its solution.

One valuable operating procedure is to operate intermittent-process machinery frequently, thus preventing exces-

TABLE 1
Approximate Allowable Power-Outage Times

Operation	Type	Criterion	Approx. Allowable Power-Outage Time hr.*	Special Remarks
Screening	Mech. cleaned bar	Becomes essentially plugged	1/2-24	No means provided for manual operation No means provided for manual operation
	Traveling fine screen	Becomes essentially plugged	1/12-24	
Pumping I	Raw water	Treatment plant shut down	1-48	
Sedimentation Primary	Sludge removed by flushing	Sludge-cake build-up	24	One reply only No replies
	Circular	Scrapers become mired	1-48	
	Rectangular	Scrapers become mired	24	
	Sludge removed by flushing	Sludge-cake build-up	24	
Secondary	Circular tank	Scrapers become mired	1-24	One reply only No replies
	Rectangular tank with scrapers	Scrapers become mired	24-168	
Chemical Feeds				
Preliminary lime		Excessive filter washes	1/6-24	One reply only
Final lime		Excessive filter washes	1	
Filter alum		Excessive filter washes	1/6-Indefinite	
Ferrous sulfate		Excessive filter washes	1/2-1	When used to increase alkalinity
Ferric chloride		Excessive filter washes	1/2	
Ferric sulfate		Excessive filter washes	1/2-12	
Soda ash		Excessive filter washes	1/2-1	When used to increase alkalinity
Soda ash		Softening effect lost	Indefinite	
Prechlorination	Gas-solution	Inadequate disinfection	1/6-Indefinite	
Postchlorination	Gas-solution	Inadequate disinfection	0-Indefinite	Zero time caused by use of electric-solenoid valves
Carbon		Foreign tastes	1/2-3	
Fluoride			1-Indefinite	
Anticorrosive additives			Indefinite	
Mixers		Excessive filter washes	Indefinite	
Flash		Excessive filter washes	1/4-24	
Flocculators		Excessive filter washes	1/4-24	
Pumping II	Wash water	Loss of use of filters	6-48	When equipped with wash water storage tank; no interconnection between mains and tank
	Wash water	Loss of use of filters	Indefinite	
	Main distribution	Pressure failure in main	0-5 min	When equipped with or without water storage tank; supplied from mains
	Main distribution	Pressure failure in main	3-5	
Lighting				
Building interior			Not critical	No national code applies; emergency lighting desirable
Building exterior			Not critical	No national code applies; emergency lighting desirable

* Unless otherwise noted.

sive accumulation of materials. The mechanically cleaned fine screen, for instance, should not be allowed to become badly covered before cleaning is started. A power failure at a time when the screen is almost plugged allows very little time for corrective measures.

TABLE 2

*Reliability Standards for Small Consumers Served by One Electric Utility**

Class	Yearly Interruptions per Customer	Yearly Outage Time per Customer† min
Urban	1.5	60
Rural	3.0	120

* Consumers included residential, small commercial, and small industrial customers of the utility.

† Outages of 2 min or less were not included.

Purchased-Power Reliability

The electric utilities have been remarkably successful in providing service reliability that meets the reasonable needs of their customers, even though some amount of service interruption is unavoidable.

A utility system consists of generators with prime movers and station auxiliaries, transformers, circuit breakers and other switching and protective equipment, overhead lines, and underground cables. These components are integrated into a system specifically designed for economically serving all of the load in a particular large area.

High reliability in the backbone of the system is accomplished by [1] subdividing the generating capacity into a number of units, usually in more than one station, [2] using parallel or loop arrangements in the system connecting circuits, and [3] often using interconnection ties with adjoining utility systems. It is also necessary to maintain certain amounts of reserve capacity at various points in the system so that

the loss of any component can be handled.

The generating and transmission part of the system serves numerous substations which, in turn, supply the distribution circuits and finally the service connections to each consumer. The service reliability for an individual

TABLE 3

*Reliability Standards for Large Consumers Served by High-Tension Line**

Class	Max. Customer Demand kw	Yearly Interruptions per Customer	Yearly Outage Time† per Customer—min
I	Over 7,500	1.5	30
II	1,001–7,500	3.0	60
III	0–1,000	6.0	120

* Consumers included large commercial and industrial customers. Voltage of the high-tension line was 12 kv or more.

† Outages of 2 min or less were not included.

customer will be affected by some single failures in the distribution circuits and also by all troubles in the typical single-circuit service to the user. The customary service for a given load at a particular location may not be reliable enough for a water plant. This question of adequate reliability, along with many other details of the purchased-power service, should be carefully reviewed with the power company as early as possible.

The best progress in the solution of the problem can be made when the water plant representatives are prepared to state their problem in terms of estimated permissible outage times for the more critical loads. A comparison between such data and the expected reliability of the proposed service will indicate whether improved service reliability will be necessary to meet reasonable objectives in the water plant performance.

Most power companies can provide information on probable service inter-

ruptions out of their operating records. One large electric utility has established the reliability standards (1) shown in Tables 2 and 3. These standards were based on a 4-year record of operations and on the probability that the limits would be exceeded only once in seven outages.

sible for the power company to provide the improvement needed in a single-service connection by supplying from some other point in the utility system, perhaps at a different voltage. Another solution, more often found in larger plants, is the use of more than one incoming line.

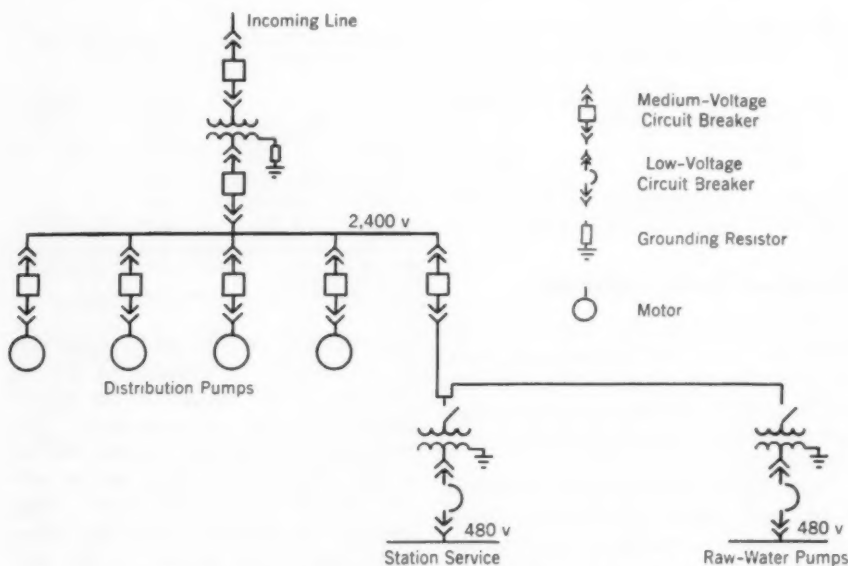


Fig. 1. Straight Radial Power Distribution System

This form of interconnection is the simplest method and makes the most economical use of equipment.

The usual reference terms for outages are "interruptions per year" and "total outage time per year," although a more useful term for many power users would be the maximum time for a single expected outage.

In cases where a proposed service reliability does not appear to be adequate, a mutually satisfactory arrangement can usually be worked out with the power company. It may be pos-

Two incoming lines in any of the arrangements termed "duplicate service," "loop service," or "preferred-emergency service" can give the very best in reliability. The actual reliability of a particular service, however, will depend on the extent to which the service arrangement insures that a single failure in the system, or in one of the incoming lines, will not cause a power outage for both lines.

Power-Distribution System Reliability

The water-plant power-distribution system carries the incoming power from the purchased-power service conductors through one or more plant busses that supply plant feeder circuits. The distribution system is thus the link between the utility system and a second part of the plant electric system which includes motor- and lighting-loads and the branch circuits that supply them.

The principal items of power-distribution equipment include incoming-line and plant-feeder switching equipment, cable, and any transformers needed to provide voltage levels suitable for the load equipment. A system can be formed by interconnecting a selected group of components according to a plan designed to meet the requirements of a particular installation.

Radial System

The straight radial method of interconnection is the simplest form and makes the most economical use of equipment. The radial method is characterized by single circuit or power channel from any point in the system toward any single load. Whenever a power circuit is opened, either intentionally or as a result of a failure, an outage is produced for some part of the load. The entire plant load will be affected if the failure occurs in the circuit that supplies the plant main bus. Figure 1 is a one-line diagram of a straight radial system. It can be seen that a greater amount of the load will be lost as the point of failure is moved back toward the single incoming line.

Components ought to be taken out of service occasionally for maintenance reasons, and this always causes a load interruption. Some maintenance op-

erations will cause interruptions of only a few minutes. The maintenance of a removable circuit breaker is an example of this, provided a spare breaker is available. Other maintenance operations, however, cause load interruptions which last as long as several hours.

Every system component is subject to possible failure that may produce a forced circuit outage, and again, if the plant has a radial distribution system, a load outage results. Some failures can certainly be corrected within an hour, but serious failures in major components might require days or even weeks for repair or replacement.

These possible circuit-outage times extend far beyond many of the allowable outage times for processes in almost any water plant. It is logical to question whether the probability of component failure is low enough to warrant risking extended outages, provided that the maintenance interruptions could be accepted. Although the failure probability of distribution equipment is known to be generally low, the statistical information is unfortunately so meager and variable as to be almost useless in a calculated-risk approach.

Radial power distribution possesses a number of desirable characteristics, however, and should not be casually rejected in planning water plant systems. The comments in the previous paragraphs do not definitely prove that radial distribution will necessarily fail to give acceptable service reliability in all water plant systems. On the other hand, it cannot be shown from available data that a radial system will provide the reliability desired in any water plant operation.

Duplicate-Circuit System

There are types of systems that can greatly reduce or even prevent load

outage times, and the feature which characterizes all of the modified system arrangements is that duplicate or alternative circuits are provided around parts of the system for maintenance access and for bypassing selected points of possible failure. A system will seldom need complete duplication or full

tion, the amount of reserve capacity included, and the circuit arrangements selected. Actual cases usually show increased distribution equipment costs ranging from about 15-50 per cent above those for straight radial distribution. In terms of total project cost, these percentages become very small.

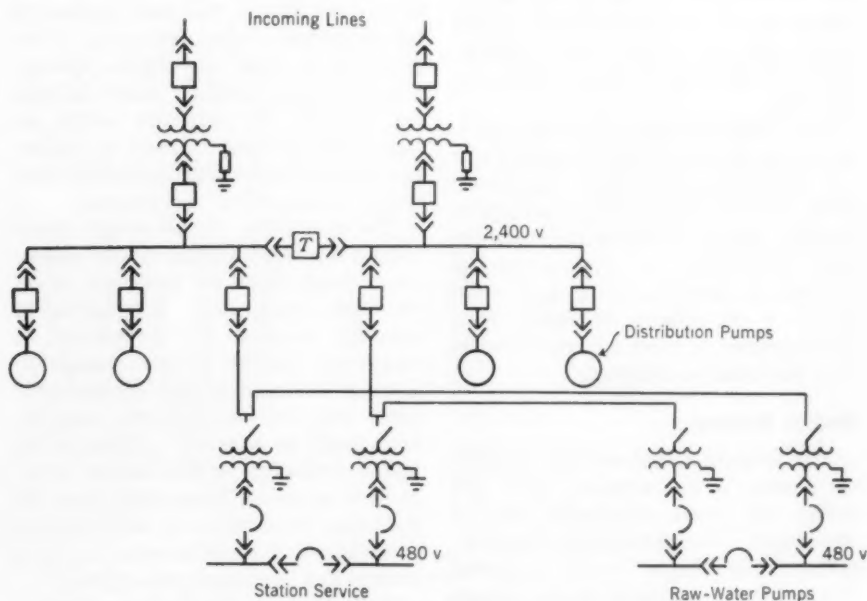


Fig. 2. Duplicate-Circuit Power Distribution System

All modifications of the straight radial system are characterized by duplicate or alternate circuits which provide means of bypassing points of possible failure.

reserve capacity in attempting to meet practical objectives, but there will necessarily be more equipment than would be needed in a straight radial system. The additional equipment can be thought of as installed spare equipment that is either used normally or can be quickly, perhaps automatically, placed in service.

The cost of this additional equipment will vary with the extent of duplica-

The increased amount of equipment, along with a tendency toward greater complication of the system, will lead to more, rather than less, component trouble and maintenance. The net gain in system reliability must therefore come entirely from reductions in functional outage times. As the outage times are progressively reduced by methods of switching load, the equipment cost and complication are both increased.

Where switching operations are performed by an operator, they can be handled in a matter of minutes after the condition is observed. If automatic transfer is employed, the interruption is limited to 1 or 2 sec. If a faulty circuit is automatically removed from a parallel connection by a suitable relaying and switching scheme, the load equipment experiences a disturbance lasting only a fraction of a second.

Some of the most useful arrangements for duplication in water plant electrical systems are illustrated in Fig. 2. The low-voltage station-service busses would handle lighting, wash-water pumps, sedimentation equipment, chemical feeders, valves, and other items. The system shown could be considered an alternative system for serving the plant using the straight radial system of Fig. 1, and the two

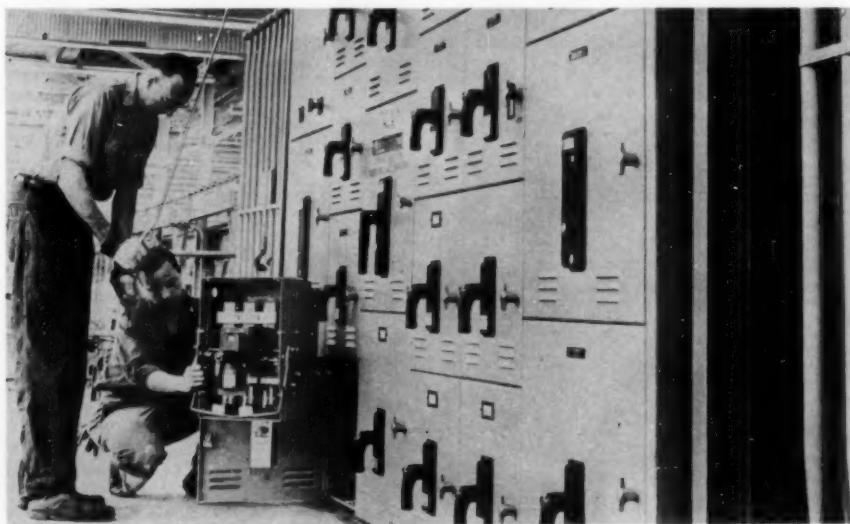


Fig. 3. Low-Voltage Draw-Out Switchgear

One low-voltage circuit breaker has been withdrawn from its operating position.

There are many approved variations of incorporating circuit duplication into system plans. Any simple classification of possible methods may give a wrong impression, because what is suitable for one case may be very poor for another. One thing to be particularly guarded against, however, is the possibility of losing the real benefits of a sound arrangement by adopting unsound modifications and substitutions to reduce costs.

illustrations give an interesting comparison of the equipment differences between the simplest system and one that provides very good insurance against extended process outage. The power supply in Fig. 2 is shown as a duplicate service from the power company. This ordinarily means much better reliability in the purchased-power supply than could be expected from a single line. A separate transformer is used in each line, providing

separate circuits for even the section-alized 2,400-v main bus. Each transformer has automatically controlled fans which increase their capacity by approximately 25 per cent. This is a very economical means of increasing the emergency capacity of either unit when the other line or transformer is out of service.

The substation transformers in a system such as in Fig. 2 are normally op-

distribution pumps are adequate depends on the relation between the plant demand and the capacity in these two pumps. Service could be reestablished to all four low-voltage busses by closing the two 480-v bus-tie circuit breakers.

Double-transformer, load-center unit substations are shown, one for the station auxiliaries and miscellaneous power, and another for the raw-water



Fig. 4. Medium-Voltage Metal-clad Switchgear

An oilless circuit breaker is being removed from its cubicle.

erated in parallel with the bus-tie circuit-breaker T closed. If either source fails it will be automatically disconnected from the main bus, and none of the load will be dropped. If any circuit breaker in an outgoing circuit from the main bus should fail to clear a short circuit, or if a failure should develop in either bus section, that section would be cleared by automatic operation of its source breaker and the tie breaker. The plant circuits connected to the remaining bus section would be unaffected. Whether the two remaining

pumps at a more remote location. Such substations with normally open secondary bus-tie breakers are a generally satisfactory solution for the low-voltage power requirements. They provide the same kind of protection described above for the plant main substation except that manual switching is more commonly used.

The above comments have covered only the main power equipment and circuits. Some control functions and auxiliary drives or devices are essential to the successful performance of

some parts of every system. Such auxiliary arrangements and the power supplies for them must therefore receive as careful attention as do the power equipment problems. It would certainly be an oversight to use a common d-c excitation bus for several synchronous motor-driven pumps where the hydraulic and main a-c power sup-

of system. There are details of selection and coordination and numerous others that must be capably worked out for each system in order to approach the performance reliability obtainable from the particular system chosen.

In planning the system details, reliability, as a separate system characteristic, requires no particular emphasis.

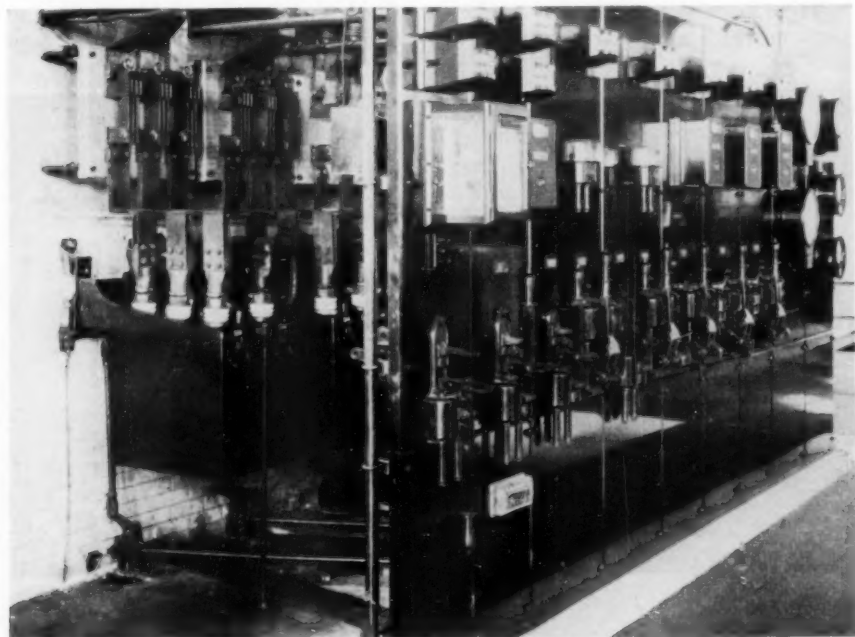


Fig. 5. Open Switchboard

This type of obsolete equipment gives a very low degree of reliability.

ply arrangements provided good protection against simultaneous shutdown from a single failure. The power supply for an electrically operated cone valve is another example of a motor drive detail that must not be neglected.

Completing System Plans

A complete system plan presents many engineering problems in addition to the important one of choosing a type

It is a significant fact that design emphasis directed at almost any desirable system characteristic will tend to favor reliability. The foundation for reliability must be laid in the initial plans and specifications. This planning work should be in the hands of an experienced electrical engineer with good technical training, a familiarity with equipment capabilities, and a knowledge of the provisions necessary for

safe and convenient maintenance operations. Good judgment in applying sound practices and principles is also necessary. Inasmuch as reliability in either the system or a component cannot be directly specified, the engineer must carefully describe desired functions and a large number of the physical and performance details of selected equipment.

The following examples suggest ways in which a well written specifica-

Another advantage of using standard equipment is that, in the event of trouble, renewal parts and service can be more readily obtained.

[2] Switching equipment of all types can be subjected to the effects of high short-circuit currents as well as normal-load currents. Circuit-disconnecting devices without adequate interrupting rating can sometimes be interlocked with other suitable devices to guard against excessive opening duty

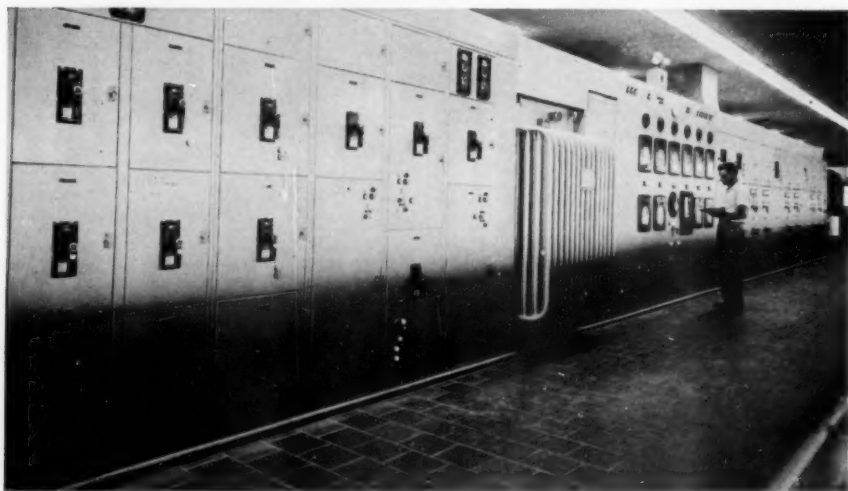


Fig. 6. Metal-enclosed Substation Line-Up

Section in the foreground is a unit substation. Section toward the rear is a hydraulic supervisory control.

tion could recognize and call for reliable equipment and reliable system performance:

[1] The specification of equipment according to the applicable standards of the American Standards Association, the National Electrical Manufacturers Association, and the American Institute of Electrical Engineers is good insurance that details not mentioned in the bidding specifications will be handled in generally approved ways.

or to prevent wrong switching sequences that might produce forced outages. Circuit breakers should always be selected with interrupting ratings at least as high as the maximum duties in the circuits where they will be used.

[3] Removable circuit breakers are a valuable aid in providing a safe and fast method of substituting a spare unit for one needing maintenance. Figure 3 shows a low-voltage, draw-out circuit breaker removed from its normal op-

erating position. The corresponding arrangement illustrated in Fig. 4 is standard for the circuit breakers used in metal-clad switchgear for higher system voltages (2,400–13,800 v).

[4] System- and component-over-current protection is provided by fuses, or direct-acting trips and relays actuating circuit breakers. When these devices have been competently selected and adjusted in a well engineered system, the damage from a fault will be limited and no part of the system will be unnecessarily included in the resulting outage. This latter characteristic of a protective system is called selectivity.

[5] Indoor equipment should be completely metal-enclosed. Figure 5 shows an old-style switchboard which was once used in various kinds of distribution equipment. Even if this open-type equipment is placed in a vault, as is usually necessary if it is to meet the requirements of installation codes, it still has shortcomings. It is not only more hazardous to personnel, but it is much more subject to outage from accidental contacts with live parts, from rodents, and from some ambient conditions. Figure 6 shows a load center unit substation as an example of modern metal-enclosed equipment.

[6] Neutral grounding of a system is now widely endorsed and accepted for all voltage levels in an industrial plant. One important advantage is a positive control of transient overvoltages, that may reach damaging levels in ungrounded systems from a variety of circumstances. Systems rated 600 v or less employ solid neutral grounding. It is feasible in higher-voltage systems to reduce the equipment damage when a ground fault occurs by limiting the fault current to a low level, usually about equal to the normal line current from the source. The ground-fault

current is limited by a neutral resistor similar to the one shown in Fig. 7 for neutral grounding of an outdoor substation transformer.

Steps After Planning

After the planning, continued effort must be applied through the stages of procurement, installation, and operation. Good quality equipment must be

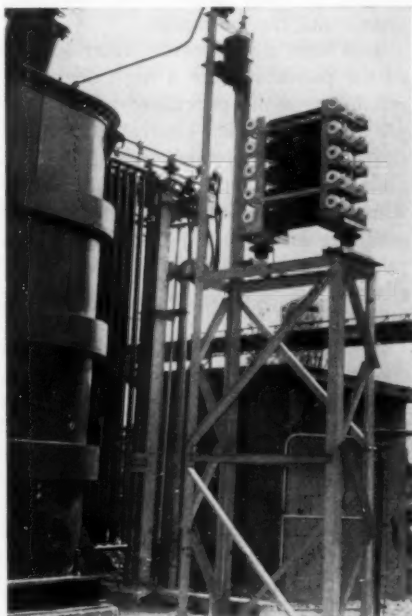


Fig. 7. Neutral Grounding Resistor

The resistor in this outdoor substation is for limiting ground fault current.

furnished according to specifications. The specifications should be clear, but it is also advisable, in the ordinary routine of bidding and purchasing, to make sure that the intent is understood and complied with. The equipment must then be installed by reputable contractors, under engineering supervision which is qualified to approve necessary changes or substitutions

without lowering the quality of the installation. During its operating life the equipment must be adequately maintained according to a planned schedule. If these measures are not taken, the original reliability will gradually tend to disappear.

Summary

To summarize what has been discussed in this paper, the following statements can be made:

1. Plants that provide water service to the public require a high degree of reliability in the purchased-power supply and in the plant electric system.

2. Power companies, consulting engineers, equipment suppliers, and the water plant officials responsible for planning and operating the plant, can jointly contribute toward obtaining an electrical installation of adequate reliability.

3. One valuable planning step is analysis of plant functions to establish allowable power-outage times for each process. From these, the corresponding times for the electrical loads associated with each process can be determined.

4. During negotiations with the power company, the process-outage tol-

erances should be available as criteria for the service reliability needed in the purchased-power supply.

5. The water plant power distribution system should be planned by a competent electrical engineer who will emphasize performance reliability and recognize the process-outage tolerances.

6. The process-outage data will particularly influence a selection between straight radial distribution and other modified forms which provide a more nearly predictable control of possible outage duration.

7. Good basic reliability as an objective, in all forms of distribution, is favored by the capable engineering of each system detail and clear coverage of numerous features and characteristics in the plans and specifications.

8. Further steps beyond engineering planning which contribute to final reliable performance are selection of high-quality equipment, correct installation by experienced contractors, and careful maintenance at regular intervals by the operating personnel.

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Selecting Adequate Electrical Switching Equipment

Joel P. Kesler

A paper presented on Jun. 15, 1955, at the Annual Conference, Chicago, Ill., by Joel P. Kesler, Elec. Engr., Black and Veatch, Kansas City, Mo.

ELECTRICAL energy is the power predominately employed today to drive the nation's water utility pumps. It is expected that electricity will remain the favored form of energy for driving the pumps to meet the phenomenal water demands of the future. With electricity playing this important part in the water utility industry, industry management should know the application fundamentals involved in each major electrical component. To some extent, the fundamentals are already generally understood. It is common knowledge that a motor must be matched to the system voltage and frequency and, like all drives, must have proper speed and capacity for its associated load. Similarly, it is understood that wiring and such equipment as transformers must have proper voltage characteristics and power-carrying ability.

An understanding of electrical switching equipment would appear to be equally simple, but, because of a lack of knowledge in this area, there are numerous installations in all industries, including the water utility industry, in which inadequate equipment is in use (1). Most of those installations have been in existence for many years and their inadequacy has arisen from enlargement of the electrical supply system over the years to serve the in-

creased electric load requirements. In the water utility industry, additional pumps or larger pumps with electric motors have too often been installed with a minimum of attention to the switching equipment. As a result, there are many installations which are hazardous to life and property as well as deficient in reliability.

Electrical Switching Equipment

The term "electrical switching equipment" refers to devices for starting and stopping the flow of electric power. An electrical switch in some respects is analogous to a hydraulic valve. In this article, electrical switching equipment includes the simple knife switch, the manual and magnetic-motor starter, the circuit breaker, and any device having contacts which close and open a power circuit. Although it is not a switch in itself, the power fuse is also included because of its frequent application in switching equipment. Not included, however, are devices for providing convenient operation or which give to switching equipment its automatic or discriminating responses, such as protective and auxiliary relays, pressure and level switches, and other control and interlocking devices.

Any electrical switching equipment, to be adequate, must be satisfactory in several respects. Like a motor or

transformer, it must be designed for full-load performance and be mated to the electric system. Also, it must be expandable into a multitude of switches or auxiliary devices, which are added to make the equipment adequate for specific services, such as acting as a controller for a variable-speed motor. Adequacy requirements of this type, on a functional basis, are readily comprehended. There is another adequacy requirement, however, which concerns the ability of the electrical switching

Low voltage-motor starters are manufactured with a short circuit-handling ability of only ten times their full-load rating (3). This rating, in some systems, is less than 5 per cent of actual short-circuit requirements. Motor starters alone are not enough protection, therefore, and their installation is made adequate only through the use of fused switches or small circuit breakers. These devices, applied on the power supply side of the starters to provide the necessary short-circuit protection, are required by the *National Electrical Code*. This code, incidentally, does not cover application of the higher-voltage equipment as explicitly as it covers low-voltage equipment. As a result, deficiencies in short circuit-handling ability are much more likely in the higher-voltage installations.

Short Circuits

An ideal installation would be one in which no short circuit could ever occur. With the present development of the electrical art, however, such an installation is not feasible. New installations must employ available equipment and materials which occasionally prove faulty. Cables are particularly subject to failures caused by improper installation or termination. Older cables, whose insulating and jacketing materials are inferior to those of today, usually tend to deteriorate through the years. Insulation deterioration also exists in equipment such as motors and transformers. There will always be the possibility of errors in the manufacturing and inspection processes. The fact that short circuits can and do occur must be accepted, therefore, and, because this is so, switching equipment which can withstand the forces involved in short circuits must be provided and must be able to open the circuit quickly

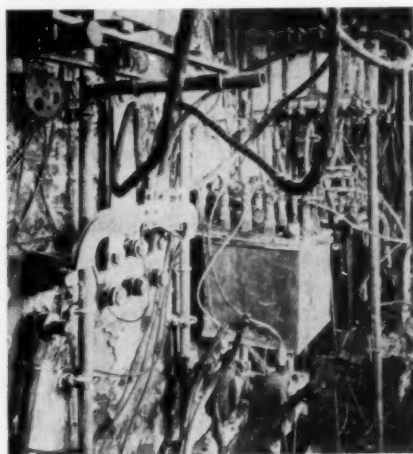


Fig. 1. Damage Caused by Short Circuit
The short circuit occurred in circuit breaker-type equipment.

equipment to perform satisfactorily under a fault or short circuit, and it is in this respect that many existing installations are deficient and are potential hazards.

Many of the smaller installations involve low-voltage equipment (220 or 440 v). Application of this equipment is clearly set forth in the *National Electrical Code* (2). Such installations usually involve motor starters for starting and stopping motors and protecting them against damaging overloads.

in order to minimize the disturbance and damage. Under short-circuit conditions, the energy involved may be many times greater than what is considered normal.

Magnetic Forces

As is generally understood, the flow of an electric current creates a magnetic field. Because of this magnetic field, electric motors produce useful torque, and electric solenoids cause contactors and relays to function. In many other ways this magnetic field is usefully employed. Under some conditions, how-

strength to resist the distortion caused by a serious short circuit. Manufacturers of switching devices fully recognize this phenomenon and accordingly apply a momentary rating to their equipment.

Electric Arc

An electric arc is a very destructive phenomenon which usually accompanies a short circuit. Once a short circuit causes a switch to open, a second arc is created within the switch as its contacts part. The heat energy of this internal arc, like the magnetic forces

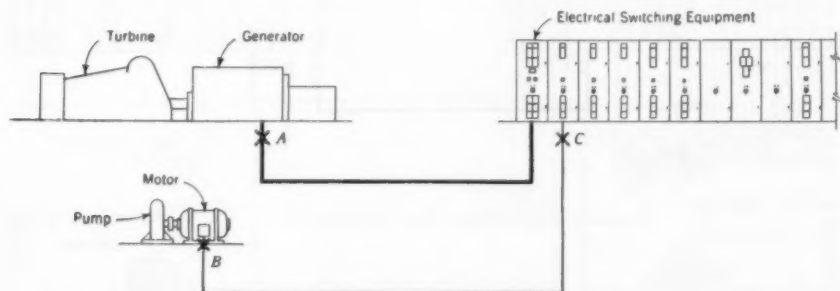


Fig. 2. Simple Electrical System

A short circuit at A may cause a current flow which is ten times greater than the generator's full-load current. A short circuit at B will be slightly less than at A, but 200 times the full-load motor current.

ever, the magnetic forces associated with the flow of electric currents can become so great that they are damaging. This is because short-circuit currents are usually many times greater than normal current, and the magnetic force varies as the square of the current. Accordingly, if the short-circuit current is 20 times the normal current, the magnetic force between conductors or between switch parts will be 400 times the normal force. Because of these tremendous increases in magnetic force, many of the older switching-equipment installations in use today are probably not of adequate

just described, tends to vary as the square of the current. The ability of a protective device—be it circuit breaker, starter, or fuse—to extinguish its internal arc and thus shut off the flow of short-circuit power is known as interrupting capacity.

Since the local danger and damage caused by an electric arc is largely proportional to the time duration of the short circuit, it is essential that the circuit be isolated quickly. Isolation of the shorted circuit is also necessary for minimizing disturbance to the electrical system so that other essential electrical devices are not affected. As a result,

a tremendous amount of ingenuity and experimentation has been, and will continue to be, employed by designers to produce switching equipment with both an adequate interrupting capacity and a minimum of arcing time.

Any modern circuit breaker is capable of completely extinguishing its internal arc and thus isolating a shorted circuit quickly after the associated relay causes it to function. Circuit breakers for 2,400-v service and higher extinguish their arcs in about $\frac{1}{8}$ sec.

entire facility. A disastrous fire may even result if the destroyed equipment is of the oil-filled type. The results of a failure caused by inadequate interrupting ability are shown in Fig. 1. The equipment in the photograph had been of the circuit-breaker type, rated 2,400 v and higher, and there are many similar installations yet in existence. There are also numerous installations of the old manual-type, lever-operated, 2,400-v, motor-starting switches which, like the low-voltage

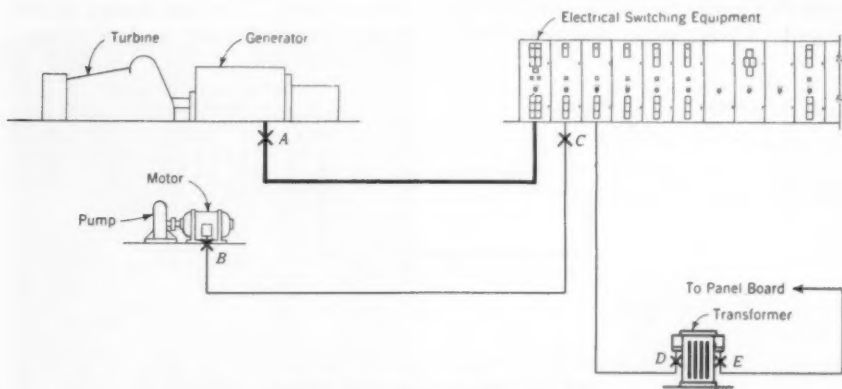


Fig. 3. Simple Electrical System With Auxiliary Transformer

Short-circuit currents at C and D will approximate those at A and B. Because of the impedance of the small transformer, the short-circuit magnitude at E will be restricted to 4 per cent of the possible value at D.

Low-voltage breakers, as employed on 240- and 480-v systems, respond even more quickly and a current-limiting power fuse can extinguish its arc within 0.01 sec.

Unless a circuit-interrupting device is adequate for the system to which it is connected in both interrupting capacity and momentary rating, it may not only fail to function properly but it may also be destroyed. Under such circumstances the destruction of the switching device will often result in damage to other equipment and may cripple the

starters previously described, have but a minimum of short circuit-handling ability. Such starting switches, extensively used 20-30 years ago, are usually oil-filled, and, because of their appearance, are frequently mistaken for oil-circuit breakers. As a result, they are often credited with a short circuit-interrupting capacity which they do not possess. Because of their extreme inadequacy in short circuit-handling ability, these old 2,400-v devices represent the greatest hazard.

The number of interrupting-capacity ratings of circuit breakers, starters, and fuses, as standardized by the National Electrical Manufacturers Association (3), is adequate to permit the application of standard equipment to any electrical system. Although it is beyond the scope of this paper to set forth in detail the reasoning and rules for correctly applying electrical-switching equipment, an explanation of the philosophy involved will be attempted.

dous amount of energy, with the only significant limitation being the generator's internal impedance. (Impedance, as used in this paper, means the inherent characteristic of any electrical circuit or winding to impede or restrict the flow of electric current.) Because of the unusual amount of care taken with generator leads, however, such short circuits occur infrequently, and a more likely point of fault would be *B*, the motor terminals, where the short

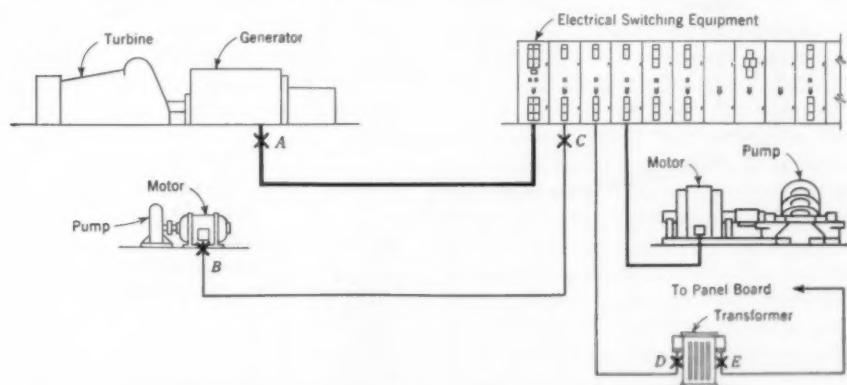


Fig. 4. Simple Electrical System With Larger Motor

The short-circuit contribution from large motors is significant. The additional motor shown here would increase all short-circuit values by 3 per cent.

Electrical Systems

Figure 2 shows a one-line diagram of a part of a typical, simple, electrical system existing in many smaller and medium-sized communities where both the electrical and water systems are municipally owned and operated. Shown in the figure is an electric generator, switching equipment, and a motor for driving a pump. Logically, the motor requirements are but a fraction of the generator capabilities. A short circuit which might occur at *A*, the terminals of the generator, will involve a tremen-

circuit will be slightly less than at *A* because of the impedance of the interconnecting conductors.

The size of the pump motor and its normal-load current have no direct bearing on the amount of short-circuit current which the circuit breaker in the second unit of switchgear will have to interrupt. Obviously, all of the short-circuit energy with which the switching equipment must cope originates in the generator. Although the motor can function as a generator and thus contribute to the short-circuit current, each contribution is of minor significance.

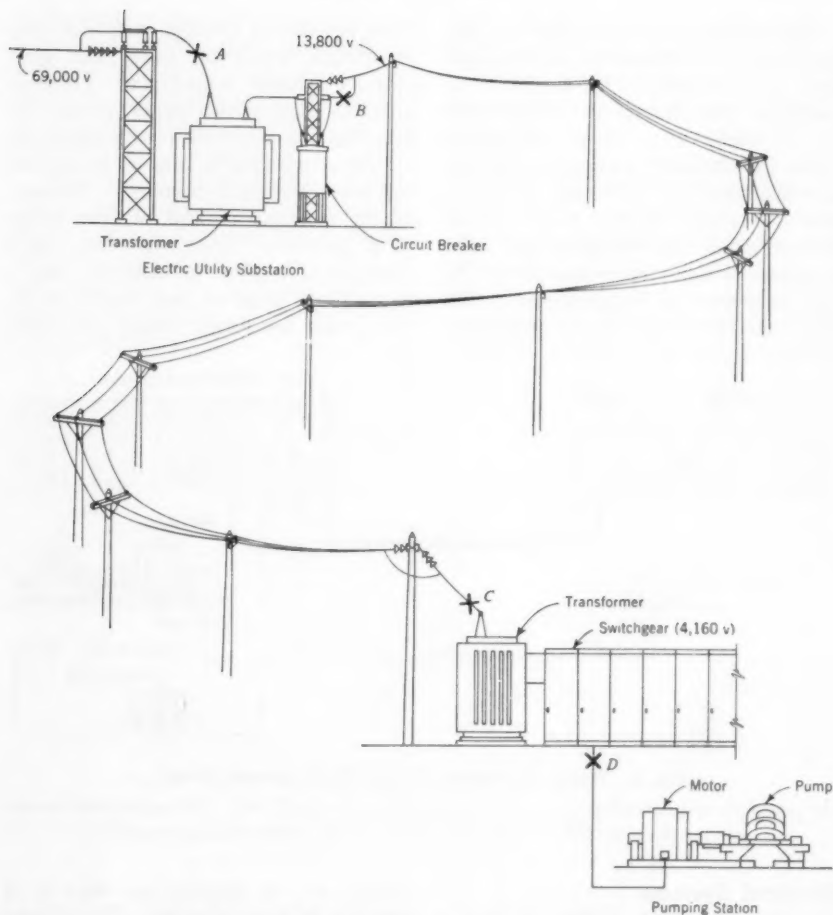


Fig. 5. Single Supply From a Large Electric Utility

Large power systems have tremendous short-circuit potentialities. The impedance of power lines and transformers materially restricts the short-circuit potentialities at the load.

Because the motor is small, it will have its feeder conductors sized accordingly. The higher impedance of these small feeder conductors will result in slight reduction in the magnitude of the short-circuit current. Therefore, with the fault at *B*, the motor size has a slight, yet indirect, effect in limiting the amount of short-circuiting current. With a fault at *C*, the motor

size will not affect the magnitude of the short-circuit current, either directly or indirectly.

The system in Fig. 3 is the same as in Fig. 2 except that a transformer is added for furnishing the station lighting and the small power requirements of low voltage. A short circuit at *D*, near the high-voltage side of the transformer, will be of approximately the

same magnitude as a fault at the motor. A short circuit at *E*, however, on the secondary side of the transformer, will be but a small fraction of the short-circuit current resulting from a fault at *D*. The impedance of the relatively small transformer will so restrict the short-circuit current that small, molded-case circuit breakers or cartridge fuses, as employed in lighting panelboards, will be entirely safe and adequate.

Typical short circuit-current values which might be encountered in a plant involving a single 7,500-kw turbine generator, a 500-hp motor, and a 225-kva lighting transformer are shown in Table 1. Data in this table demonstrate

TABLE 1
Normal- and Short-Circuit Requirements Compared

Location*	Normal Current amp	Short-Circuit Current amp	Short-Circuit Magnitude† kva
A and C	1,300	13,900	100,000
B	61	12,600	91,000
D	31	12,600	91,000
E	270	4,200	3,800

* Operating voltage at A, B, C, and D is 4,160 v and at E, 480 v.

† Kilovolt-amperes (apparent power) is preferable to amperes (current) for comparing short-circuit magnitudes, particularly where different voltages are involved.

the large ratio of normal to short-circuit currents. The motor short-circuit current is more than 200 times the normal, or full-load, motor current and the transformer short-circuit current, on the primary side, is 400 times the normal, or full-load, transformer current. Also shown is the effectiveness of the small transformer in limiting the short-circuit kilovolt-amperes on its secondary side.

If a 15,000-kw turbine generator is employed instead of the 7,500-kw machine, the short-circuit currents at A and C will be doubled, that is, or in direct proportion to the generator size. Similarly, short-circuit currents at B

and D will be approximately doubled, but those at E will be changed only slightly.

Few generating stations, particularly those of the type illustrated, consist of only one generator. Assuming that the station contains several machines, with a total rated capacity of 15,000 kw, the resulting short-circuit current will be the same as that which would flow from a single 15,000-kw machine. Obviously, only machines that are running and connected to the system can contribute to the short-circuit current.

Regardless of the changes in the electrical system, the small transformer is so effective in limiting the short-circuit current at E that under no circumstances can the generator contribute more than 4,200 kva—an increase of 10 per cent at this point. Similarly, since residences are fed from even smaller transformers, with correspondingly greater impeding characteristics, the miniature circuit breakers and plug fuses used in the home are entirely adequate for the duty imposed.

A station employing engine-type drives will have one-half the short-circuit potentiality that a turbine station of an equivalent capacity would have. This is true because engine-driven salient-pole generators, as usually encountered, have approximately twice the impedance of high-speed turbine-type generators.

Motor Contribution

As was already mentioned, the short-circuit contribution from motors is usually of minor importance, but it cannot be entirely neglected. A second motor added to a station, as shown in Fig. 3, will respond like a generator in contributing to the short-circuit current. If the motor is of the induction type, as is frequently encountered, its significant contribution will last for only a

few cycles. A synchronous motor, which, like a generator, has a separately excited d-c field, however, will convert part of its rotating energy into electric power, which is contributed to the short circuit. Fortunately, synchronous motors not only look like engine-type generators, but also have similar high impedances. Consequently, if the motor added to the system shown in Fig. 4 is of the synchronous type and

mission substation in which electrical power is transformed from 69,000 v to 13,800 v by a 25,000-kva transformer, and then distributed from that point to major load centers in the vicinity. A number of 13,800-v circuit breakers are used in such a substation, but only the one supplying the water-pumping station is shown. At the pumping station, power is further transformed through a 6,000-kva transformer to 4,160 v and



Fig. 6. Metal-clad Switchgear

The switchgear shown is 2,400-v equipment in the foreground, 12,000-v at the back.

is rated 750 hp, its contribution to the short circuit at *C* will be approximately 3,000 kva, increasing the total at that point by only 3 per cent.

Large Electrical System

The principles involved in small- and medium-sized electrical systems also apply to the large systems. Because of the impedances of lines and transformers in a large system, the short-circuit currents are minimized. Figure 5 shows a portion of a large subtrans-

fed through switching equipment to several 2,000-hp synchronous motors which serve as pump drives. Although the available short-circuit current is 1,500,000 kva at *A*, the high-voltage side of the large power transformer, this will be reduced to 250,000 kva at *B* because of the transformer impedance. The line from the substation to the pumping station will further reduce the available short-circuit current to 200,000 kva at *C*, the 13.8-kv side of the pumping-station transformer. Fi-

nally, the impedance of the relatively small transformer at the pumping station will reduce the short-circuit duty on the associated electrical switching equipment to 65,000 kva at *D*.

Reliability Requirements

Reliable electric service obviously cannot be assured with only one feeder and one pumping-station transformer.

rated 150,000 kva. The available short-circuit current is so close to the rating of the breaker, however, that any significant change on the part of the electric utility system would make the switching equipment inadequate. Since 250,000-kva equipment is available at a slightly higher cost than the 150,000-kva equipment, the higher rated equipment should definitely be applied.

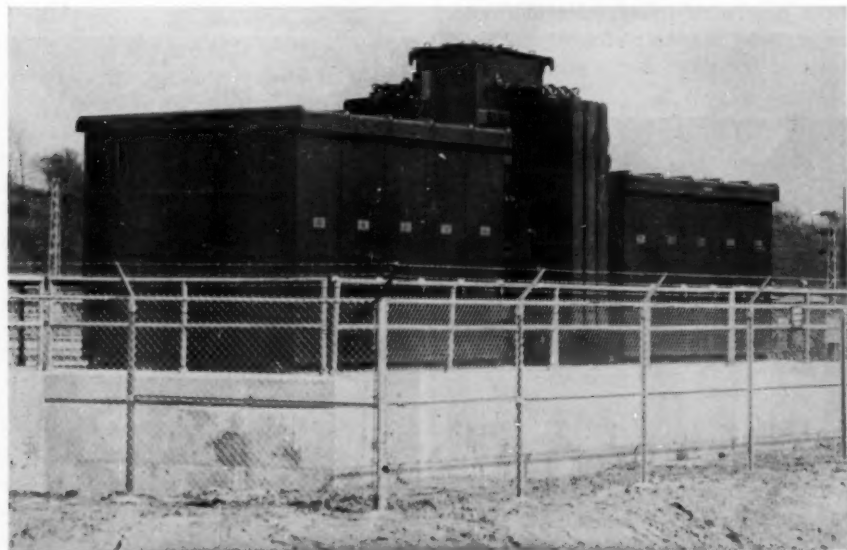


Fig. 7. Metal-clad Switchgear Used Outdoors

The switchgear is assembled with a transformer to form a unit substation.

Even the electric utility substation can fail. Consequently, to achieve the greatest reliability, a second feeder, originating from a different point on the electric utility system, and a second pumping-station transformer should be provided. Such an arrangement will result in approximately doubling the short-circuit duty on the electrical switching equipment. Considering also the motor contribution, the smallest available circuit breaker which can safely be applied in this instance is

It is possible that 20 years after the water-pumping station is built the electrical requirements will be doubled as a result of gradual or concentrated expansion in water-pumping requirements. Larger electrical-supply facilities will then be necessary, particularly in the size of the pumping-station transformers. Under such conditions, even the larger-sized switching equipment, with its large initial safety margin, will be inadequate in its interrupting rating. The initial installation could have been

provided with still larger switching equipment of course, to allow for such long-time changes, but such a procedure is seldom feasible because extensive oversizing represents an investment on which the extra financing costs alone will usually offset any long-time saving. Since the electrical art is relatively new, equipment purchased 20 years from now will conceivably have many incidental advantages over equipment purchased today. Furthermore, the increase in water requirements can often be served to better advantage by

however, is not only necessary for good electric performance, but the lower impedances themselves also have advantages. With them, power losses and voltage fluctuations are minimized. These lower impedances have resulted in a trend toward relaxing the restrictions on full-voltage starting of large motors. As a result, simpler and less expensive starting equipment can be employed.

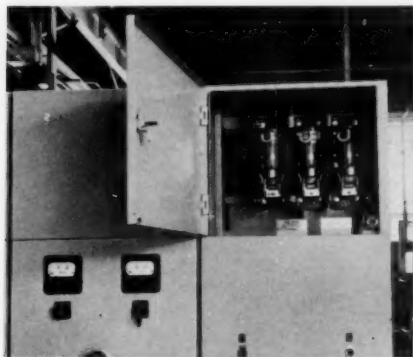


Fig. 8. Fuse-Contactor Combination

The fuse-contactor combination shown here is of the high-interrupting type.

creating a complete new facility rather than changing the existing station.

This same logic was applicable in the past, but now, 20 and 30 years later, many pumping stations have been expanded with corresponding electrical-system changes but with little thought given to the adequacy of the electrical-switching equipment.

This paper has emphasized the hazards of short-circuit currents resulting from large electrical systems having correspondingly lower impedances. This tendency toward lower impedances,



Fig. 9. Combination Starters

The starters are assembled into a control center.

Diminishing Hazards

The impedance of the electrical-system components can sometimes be feasibly increased within certain limits. This is particularly true of transformers, with the resulting possible advantage of retaining existing switching equipment, or, if new equipment is required, of employing less expensive

types. Impedance, in the form of a reactor, can be added to some existing systems to lengthen the safe life of the existing switching equipment. Deliberately increasing impedances involves other compromises, however, such as higher losses and poorer voltage regulation. When increases are made, caution must always be employed so that proper voltage will be maintained for satisfactory performance of motors and lighting equipment.

The addition of power fuses, especially the current-limiting type, provides another possible method of making existing switching equipment adequate, or at least of greatly minimizing the possible hazards. Equipment manufacturers offer medium-voltage starting equipment suitable for motors as powerful as 2,500 hp. This equipment consists of a combination of contactors or light-duty circuit breakers with current-limiting fuses, and will often meet all the adequacy requirements of electrical switching equipment. Many practical problems are encountered in the attempt to simulate factory products of this type by adding fuses to existing switching equipment. From a technical standpoint, it is difficult to mate modern fuses with old equipment which has unknown characteristics.

Inadequate space for proper electric clearance is another serious problem which, if not properly considered, creates a hazard to personnel. Much of the older switching equipment is actually inadequate from a safety standpoint because of its open or exposed construction. The addition of fuses to this older equipment will require personnel to expose themselves to hazards when replacing blown fuses. Such application of fuses to older equipment, therefore, if feasible at all, should be

considered as a temporary improvement rather than a permanent correction.

Some electrical-system arrangements permit an operating procedure which will minimize the short-circuit requirements. Where several sources of power are provided in a pumping station, one source is often all that need be employed at a time. Arrangement of switching equipment having a divided bus or a double bus will sometimes permit employing two sources



Fig. 10. Wall-mounted Starters

The starters are combination circuit breaker-contactor starters.

simultaneously yet separately, with one source on each bus section. Either procedure will materially curtail the short-circuit requirements of the switching equipment. There are other methods or steps which can be taken to lengthen the useful life of switching equipment, particularly if its deficiency is not great. Many existing installations, however, are so inadequate that the only satisfactory solution is to replace them completely with modern equipment.

Equipment Choice

As previously mentioned, equipment adequate for the requirements of any electric system is available for replacement or for use in new facilities. In the medium-voltage class (2,400-4,160 v) either metal-clad switchgear, as shown in Fig. 6 for indoor application and in Fig. 7 for outdoor application,

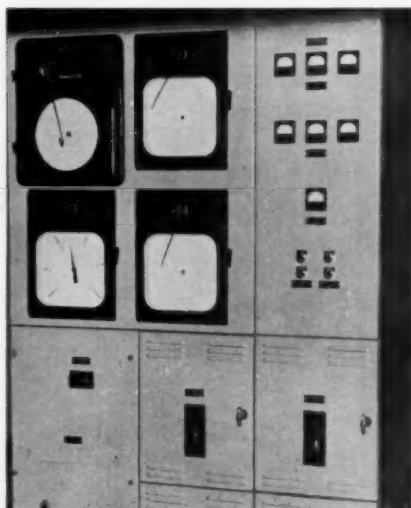


Fig. 11. Metal-enclosed Switchgear

This low-voltage switchgear includes such auxiliary devices as circuit breaker, motor starters, lighting transformer, lighting panel, station-supervisory instruments, and well-pump control and supervision.

or a high-interrupting type of fuse-contactor combination (see Fig. 8) may be selected. One manufacturer supplies an adequate medium-voltage starter in which individual current-limiting reactors are employed instead of fuses.

The choice of low-voltage switching equipment will be somewhat limited by the possible short-circuit cur-

rents. Control centers, as shown in Fig. 9, or wall-mounted starters, in Fig. 10, are adequate in many instances, particularly when the interrupting requirements do not exceed 15,000 amp at 480 v, but where the interrupting capacity is in the vicinity of 25,000 amp, and sometimes with smaller capacities, metal-enclosed switchgear is often preferred because of its greater flexibility for future load growth and its excellent appearance. Because circuit breakers have definite limits on the number of normal opening and closing operations, however, the contactor-type starter is required in applications involving a number of operations each day. Figure 11 shows an application of low-voltage metal-enclosed switchgear which includes many auxiliary devices.

In selecting the most suitable electrical switching equipment, costs must be considered. Obviously, any cost comparison must be made on an installed basis. In some situations, the cost differential between types of adequate equipment has been large and has dictated the choice of equipment. More frequently the differences in the installed costs of the available adequate equipment is insignificant when compared with such other considerations as ease of maintenance, appearance, and flexibility for meeting load changes. Consequently, general rules involving costs must be avoided in favor of individual project analysis.

Many textbooks are available for advice on the selection of electrical switching equipment. Some of the best references are available in the form of books and catalog data published by the equipment manufacturers (4-6). Personnel responsible for the proper electric performance of pumping stations should consider equipment choice

in the creation of any new facility and, particularly in the older stations, determine if previously unknown hazards exist. Where such hazards are found, they should be eliminated.

Conclusions

To summarize what has been said in this paper, the following conclusions can be drawn:

1. In many installations electrical switching equipment has become inadequate, particularly in the older stations, because of the expansion in pumping requirements and the associated changes in the electrical system. Such inadequacy represents hazards to reliable operation, personnel, and property, and has resulted frequently from failure to recognize equipment requirements.

2. Equipment can become inadequate for many reasons, but the ability of a switching device to adequately handle short circuits is the one most commonly neglected.

3. Greater inadequacy and more frequent hazards occur with older-type 2,400- and 4,160-v equipment than with low-voltage equipment of similar age. Switching equipment containing oil is considerably more hazardous.

4. Older stations should be examined closely to determine where inadequacy exists, and corrective action should be taken.

5. Relatively inexpensive, "stop-gap" provisions are sometimes feasible, but, for proper correction, extensive replacement with new equipment is usually required.

6. It is seldom possible to provide electrical switching equipment for problematical, long-range, future requirements.

7. In the selection of electrical switching equipment, it is the electrical supply system, rather than the connected load, that determines the short-circuit rating. As a result, motor starters are often physically larger and more costly than the associated motors.

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Watershed Control in Maryland

—L. G. Ningard—

A paper presented on Oct. 27, 1955, at the Chesapeake Section Meeting, Washington, D.C., by L. G. Ningard, Supt. of Watersheds, Bureau of Water Supply, Baltimore, Md.

HIGH yielding streams of superior water quality are universally associated with good, healthy, forest land. Therefore, forest management in most cases today also means watershed management.

Values of Forest Cover

It has been demonstrated by the U.S. Forest Service that an adequate forest cover, with the yearly accumulation of fallen leaves, builds up a thick humus, or mulch, of partially and completely decayed leaves and twigs on the forest floor. This accumulation serves as a sponge to hold precipitation in large amounts.

It has been found that a 6-in. layer of rich forest humus may detain as much as 5 in. of rainfall. Within a period of 4 or 5 days, more than half of this water is given up to the underlying soil. The litter is then again ready to accept and hold an appreciable amount of rainfall. Water that moves through such a forest soil gradually returns to the surface weeks or months later in natural springs or stream channels which flow into the reservoirs.

Furthermore, the root systems of the trees penetrate the soil to a depth of many feet and thus create natural channels for the water to soak into the ground. Besides this, good forest cover provides protection and stability

to the soil. It also prevents deep penetration of frost and therefore helps the soil to stay more porous during the winter. Water in the form of precipitation can penetrate the forest-protected soil to a considerable depth.

For watersheds in poor condition, however, the picture is different. When the ground is bare of forest cover, or the forest mulch is destroyed by fire or grazing, the soil loses its porous structure and much of its absorptive capacity. When the surface soil is thus altered and exposed, runoff is accelerated, organic material is oxidized, and topsoil containing the rich spongy humus is picked up and carried away. Heavy rains then compact the soil and seal the surface against infiltration. Such exposed soil will freeze solidly. In this way, loss of vegetation cuts down the percolation of water into the soil. Under such conditions, fluctuations in stream flow are magnified. The streams tend to rise swiftly to flood stages during each rain, then, later, drop as quickly to very low yields or even disappear temporarily. Also, because less water gets into the soil, less water reaches the underground basins to replenish them.

The absence of cover invites erosion. Once the eroding process has started, it tends to be cumulative. The loss of the porous surface soil exposes the

denser and usually much more erosive subsoil. Damages from erosion to exposed soils may, in only a few years, become so extensive and serious that their effects will be felt for decades.

Effects of Forestation

The forest has a very favorable influence on water yield because the soil structure and porosity are favorable to infiltration, maximum storage of water, and control of erosion.

Whether forests have a more favorable influence on water yield than other types of cover has been debated by some hydrologists and water supply men. It is said that trees require more water for transpiration than do other plants, thus reducing the total amount of water that will be available on a watershed for streamflow. For example, recent studies on evapotranspiration in Utah, as reported by the U.S. Forest Service, show that aspen forest sites with a 6-ft deep root system consume about 18 in. of water per growing season, while sites with herbaceous plants having a 4-ft deep root system consume about 14 in., and bare sites lose about 10 in. These figures indicate that the losses are less on bare land, but it must be taken into consideration that there is a greater overland runoff. The forested areas will absorb water seven times as rapidly as any other type of area, and the erosion is practically nil.

Controls

Although forests use large quantities of water, man can regulate their interception and consumption of water so that the losses do not outweigh the benefits. This is managed by reduction of density of stands and removal of

old deep-rooted trees and riparian vegetation. Such management, however, must be made with due recognition that wrong practices, which may result in increased evaporation and soil erosion, can have consequences which are seriously damaging to water yield. Here again, man can control these eventualities by judicious extent of cuttings, by proper insulation of the soil surface exposed by opening of stands, and by careful logging practices.

Experimental Forests

Increasing water production through forest management is the subject of a series of experiments being conducted by the U.S. Forest Service in Coweeta, N.C., on Fernow Experimental Forest in West Virginia, and on the Fraser Experimental Forest in Colorado. One completed study, conducted on a plot basis in Colorado, has shown that judicious harvest cutting of the mature lodgepole pine timber resulted in an immediate 30-per cent increase in water yield. This study has also indicated that periodic harvesting and judicious thinning of young stands may produce a permanent increase of up to 15 per cent in water yield. There has been no indication that the cutting will cause an appreciable decline in water quality from erosion if appropriate methods of logging are used.

The Water Supply Bureau of Baltimore, Md., has a management program for its watersheds. It is realized that any management program that is carried out on 17,000 acres of land is of small consequence in relationship to the total watershed area of approximately 299,000 acres. By proper management of bureau lands, however, neighboring owners may be encouraged to follow policies that will be beneficial to them.

In general, the program covers forest land use to assure continuance of the productive and the hydrologic functions of the land, erosion prevention, recreational use of watershed area, and good sanitary conditions on the watershed.

Local Watersheds

The watershed land owned by the Water Supply Bureau surrounds three impounding reservoirs, namely, Loch Raven, Prettyboy, and Liberty. Most of the land on the Loch Raven and the Prettyboy areas is under tree cover—91 per cent at Loch Raven and 87 per cent at Prettyboy. On Liberty Watershed, which has just recently been created, the woodland comprises only 44½ per cent of the acreage.

With the exception of some periodic planting at various times, these areas have been without management. As a result, the forest stands today are dominated by a large amount of overmature, defective, and undesirable trees. These retard the reproduction of young tree growth.

The clearing operations at Liberty Dam were undertaken by the Bureau with its own forces. These forces operated a saw mill on this watershed and sawed approximately 5,000,000 board feet of lumber, 10,000 cords of pulpwood, and thousands of pieces of blocking, wedges, and surveyors stakes. This lumber was sold to the various city departments and to outside lumbermen. The value of the material disposed of was about \$783,000.

From the knowledge gained in the clearing operations at the Liberty Dam it was decided to utilize further the equipment and the men who are now employed by the bureau and to initiate

a management program on all of the reservoir properties.

Cuttings

A forest land survey has been completed of Loch Raven and Prettyboy watersheds. It revealed that on Loch Raven there are at least 15,000,000 and, on Prettyboy, 8,500,000, board feet of timber over 16 in. in diameter. All of this is ready for harvesting. To facilitate future management, the entire forests on both watersheds were divided into separate units. They were split again into separate sections, according to the dominant forest tree types.

The first cuttings are aimed at removal of all overmature, defective, and, where the stand conditions will allow, all undesirable species. The extent of cutting of these trees will be determined on the spot. Generally, a minimum reserve stand of about 3,000 board feet of high quality, vigorous trees per acre will be allowed to stand. In the next cycle, attention will be concentrated on the removal of pulpwood from the younger stands, and the cutting of mature timber. Through these practices the bureau hopes, in the future, to maintain rather young stands of trees and to improve their composition and value, to improve the soil infiltration, and, consequently, by reduction of transpiration loss while retaining a low evaporation loss, to increase the water yield from the bureau's forest lands.

To perform this task successfully, the bureau will operate its own sawmill at Loch Raven. By sawing the timber into different products, current demands on the lumber market can be accommodated, resulting in bet-

ter financial returns. All inferior grade lumber, which would otherwise be difficult to dispose of, can also be utilized in this way.

Reforestation

The city-owned lands which are not covered by trees are subject to reforestation. Extensive areas were reforested on Loch Raven Watershed in the period 1912-31. The tree-planting program was resumed again in 1948, and from that year until 1955 a total of 1,054,000 seedlings were planted. Most of them, or about 558,000, were planted on the Prettyboy Watershed and about 337,000 were planted at Loch Raven.

The future reforestation program will be mostly concentrated on the newest watershed, which is Liberty, where there are approximately 3,265 acres of bare land, according to the measurements taken from aerial maps. The Maryland State Department of Forests and Parks supplies all of the seedlings. The tree species to be used in the future are white pine, loblolly pine, and shortleaf pine, as well as black locust and tulip poplar.

Erosion Prevention

The Bureau's watershed management program gives close attention to forest-fire, insect, and disease control. To regulate erosion, close watch is kept along the shoulders and banks of the highways through the watersheds, on trails used for log skidding, and along the streams where bank cutting may occur. The eroding road banks are revegetated by grass. After the logging is completed, the skid trails are reinforced with water bars and brush

from tree tops. Stream bank cutting is also controlled by use of water bars and brush.

Recreation

Since Baltimore's watersheds are located close to a metropolitan center, the recreational use of the areas is a management problem. Although soil compaction by people has an adverse effect, the Bureau believes that the public should be permitted to enjoy its watershed holdings. For this reason, picnic areas, where the people are allowed to stay and to enjoy the magnificent scenery, have been designated on the watersheds. The rest of the area is closed to visitors. Parking lots have been built and a network of paths has been developed in the areas near the dams.

The Bureau plans to border selected areas with flowering plants. Under this program, 420 red-flowering rose ramblers were planted this year. These were raised from cuttings prepared by bureau forces.

Fishing from rowboats in the lakes is allowed. At the present time, the League of Maryland Sportsmen maintains and operates fishing stations and rowboats on Loch Raven and Prettyboy reservoirs. A total of 1,180 fishing permits were issued between Jul. 1, 1954 and Jun. 30, 1955.

Suburban Growth

In recent years the influx of population into the suburban areas has been very great. Large farms, consisting of 100 acres or more, which were occupied by a one-family house, have now been developed into small-acreage plats, some as small as $\frac{1}{4}$ acre. Although this

movement of population has occurred in all sections of the rural area, the presence of reservoirs has an extra attraction for development. This increase in housing presents a definite pollution problem for watershed management.

In most of the new developments, septic tanks with seepage pits or drainage fields must be installed. Some of these installations can be very satisfactory, but, with the wrong type of soil, not only the property owner but the water engineer and the stream-pollution authorities have a problem that is difficult to solve.

Because this problem has become acute in recent years, health authorities have rewritten many of their regulations and new legislation has been passed to control the disposal of sewage. Before a permit is issued to build a house on the watershed areas of the Water Supply Bureau, satisfactory soil tests are essential. Where possible, small sewage treatment plants and pumping stations are installed. The bureau employs a sanitary inspector who is constantly working on pollution problems, both old and new, which may affect the purity of the raw-water supply.

Discussion

R. C. Willson

Supt., Water Dept., Hagerstown, Md.

RECENTLY, after viewing material on the work being done at the experimental watershed in Coweeta, N.C., the discussor questioned H. G. Meginnis, Director of the Coweeta station, as to the conclusions of the study. Meginnis replied that no definite conclusions could be drawn as yet, because the study has been under way for only 20 years. This statement illustrates not only the conservatism of the men conducting such studies, but also shows how difficult it is to wrest from nature an understanding of some of her processes.

Even though no conclusions have been drawn from such watershed studies, the experiments seem to suggest certain indications:

1. The farming of steep slopes is unprofitable after a few years because the productive top soil is rapidly eroded and the quality of runoff deteriorates.

2. Use of timber lands for grazing purposes is harmful because the earth becomes compacted to the point that ruin is almost completely replaced by runoff. Through compaction, close cropping, and stamping, plants are eventually killed and their earth-retaining properties are lost. Subsequent runoff is then attended by erosion.

3. Deforestation greatly increases the quantity of runoff, but the quality of the water yield is low. The higher turbidity is more costly to remove, or, if the water is impounded, silting of the reservoir is increased.

4. On the other hand, proper lumbering practices not only yield revenue but improve the growing conditions of younger trees without any detrimental effects on the watershed.

Forestation

The author has mentioned planting black locust and tulip poplar. In 1939 Hagerstown planted 15,000 locust and most of them are blighted by now.

Tulip poplar is a fast-growing tree and is readily saleable at present. This and other deciduous trees, however, should not be planted near any stream. The streams and any impounding reservoir can be bordered to advantage with evergreens planted sufficiently far apart that their bottom limbs are not shed. Plantings such as this will serve as a screen to prevent the leaves of the deciduous trees from blowing into the water.

A recent proposal is that all trees within 50 ft of a stream be removed because the transpiration of such trees is excessive and further depletes the runoff. No quantitative evaluation of this procedure has been made to date.

Hagerstown obtains about 30 per cent of its water production from two watersheds on the west slope of South Mountain. The total drainage area is 4,000 acres, of which the city now owns about 30 per cent. Denuded areas of the city land have been planted largely in pines, but the trees on the watershed are mostly deciduous.

Prior to 1939, probably 75 acres of the city property was farmed. At that time, a 0.50-in. rainfall would invariably raise the turbidity in the 100-mil gal reservoir above the tolerable limit, requiring the removal of the reservoir from service until the water clarified itself by settling. Since the retirement of the land from farming use, the grasses and eventually the trees have retarded runoff and erosion so that now the runoff from 1.5 in. of rainfall at a comparable rate can be impounded without suspending use of the reservoir.

The resident caretaker on the watershed was reared in the area and has greatly improved the department's re-

lationship with the residents of the 48 houses on the drainage area. Some have been converted to the use of contour plowing. Others have periodically planted pine trees, and most of the owners of land on the watersheds have the attitude that if and when they desire to sell their land, the city of Hagerstown is the logical purchaser.

Advantage has been taken of the great and varied assistance available through the Maryland State Department of Forests and Parks, the Soil Conservation Commission, and allied agencies. These groups have much information which is beneficial to water works and they are eager to impart it.

Potomac River Watershed

Hagerstown is also involved in another watershed of an entirely different type, control of which is in the hands of other agencies. This is the Potomac River watershed, which, at the location of Hagerstown's rapid sand filter plant, drains 4,940 sq miles (3,162,000 acres) in Maryland, Pennsylvania, and West Virginia. About 3,000,000 acres (94 per cent) of this basin are privately owned. The upstream urban and rural population of the basin at Williamsport is over 250,000, and the western end of the river is a highly industrialized area.

The publicly owned areas are largely in state parks and forests and are properly controlled. In the past, the private owners in the area have grossly abused the Potomac River, without any thought of the downstream results. More recently, through the efforts of the Maryland Stream Pollution Commission and the cooperation of offending industries in Maryland, great gains have been made in the elimination of

pollution. The corresponding agency in West Virginia has also demanded and achieved many industrial corrections.

Similarly, the municipalities have heretofore freely used the Potomac River basin as a dumping ground. Through the prolonged and unrelenting pressure exerted by George L. Hall, Chief Engineer of the Maryland State Department of Health and Past Chairman of the AWWA Chesapeake Section, Cumberland is now constructing a sewage treatment plant. An official order of the state health department has also been issued to Hancock, Md., which currently is discharging untreated sewage into the Potomac River 20 miles unstream from the intake at the water treatment plant at Hagerstown. Obviously, such measures are splendid watershed controls which lie beyond the scope of cities.

Interstate Commission

Another phase of watershed control of the Potomac River involves interstate activities. Many years ago, to reconcile such problems, the Interstate Commission on the Potomac River Basin was formed. This is a cooperative organization with representatives from Maryland, Pennsylvania, West Virginia, Virginia, and the District of Columbia. The Commission has no power but has done much to coerce municipalities and industries in the respective states to tend toward contributing less pollution to the Potomac River Basin. In some matters, however, it appears that this agency cannot be as effective as is desirable without having certain powers which it does not now possess and which it is unlikely to acquire in the future. Readers familiar with the proposed Scott's Run

project in the District of Columbia are aware of all the documented evidence of pollution which the District of Columbia and Prince George County, Md., are currently imposing upon the lower Potomac River and its tributaries. Progress is being made gradually, however.

Supplemental Irrigation

Under the term "riparian rights," many persons whose land adjoins a stream believe that they have the legal right to pump from the stream as much water as they desire, without any consideration of the landowners downstream. The water withdrawn may be used for irrigation of field crops and orchards.

The minimum 1-day flow for the Potomac River at Williamsport, Md., has been calculated at about 300 mil gal, including an allowance for the discharge of the Savage River Dam. This flow, of course, would occur only during a severe drought, but such a drought would also make supplemental irrigation desirable and profitable. Theoretically, therefore, there can be foreseen a day when the unbridled growth of supplemental irrigation would draw all the water from the Potomac River before it reaches the Hagerstown intake. From a practical standpoint, such an occurrence may appear unlikely, because the drainage area includes much mountain land which is untilled and other vast acreage in timber, lands which are not to be considered as areas to be irrigated with water from the Potomac River. On the other hand, considering that the 300-mil gal minimum 1-day flow is equivalent to 1 in. of water on only 11,000 acres, and 11,000 is only 3.6 per cent of the privately owned acreage

on the drainage basin, withdrawal of all water from the Potomac by supplemental irrigation does not seem impossible.

Fortunately, this potential danger has been officially recognized and the water commission recently appointed by the governor of Maryland has been instructed to define the limitations of "riparian rights" before the waters of the upper Potomac River are completely dispersed for agrarian purposes.

Another source of river pollution, largely uncontrolled, is the acid waters flowing from abandoned coal mines in the far western part of the Potomac River Basin. These continue to contribute an undesirable constituent to the

river, but through dilution and neutralization by natural means, the water has recovered a desirable alkalinity before it reaches the Hagerstown intake.

Conclusions

For approximately 20 years, through research, education, salesmanship, reforestation, cooperation, and legislation, waters which are the source of the Hagerstown supply have been gradually pulled upward in quality from the unnatural condition they had reached as a result of manmade pollution and abuse. The progress is slow and the goal is still far ahead of us in the future, but the trend is definitely and permanently in the proper direction.



Water Service Policies for Suburban Areas

C. K. Mathews

A paper presented on Oct. 20, 1955, at the Iowa Section Meeting, Des Moines, Iowa, by C. K. Mathews, Partner, Burns and McDonnell Eng. Co., Kansas City, Mo.

IN water works parlance, the term "suburban" pertains to customers living outside of the incorporated area of the political entity which owns and operates the water utility in its proprietary capacity. This is the definition used here, and the policies discussed will apply specifically only to publicly owned utilities. Those policies which are derived from the fact that suburban areas may be sparsely settled, however, will have much in common with policies of privately owned utilities.

Suburban customers may be the public water districts, private water companies, or incorporated towns who purchase water for re-sale, or they may be occupants of single-family residences.

Recent years have been economically good years and there have been increases in population, number of automobiles, and new homes. Many of the new homes have been built in the suburbs, frequently as part of large real-estate developments. Quite often these developments have been started without proper planning for water service. These conditions have created difficult problems for the utilities in the matter of furnishing water, and have made necessary the establishment of definite policies or the modifications of existing policies relative to service to suburban customers.

The problems for which policies must be determined may be separated into four principal categories:

1. Under what conditions is the water utility obligated to furnish water service outside the city limits?

2. If the city assumes the obligation of serving suburban customers, what control of distribution system facilities in the suburban areas should be vested in the city water utility?

3. How shall improvements be financed?

4. What rates or charges shall be made for service to suburban customers?

Obligation to Serve

There are two divergent policies as to the obligation of a utility to serve suburban areas. The first is based on the philosophy that the city is not obligated to serve suburban consumers and, in fact, may refuse to do so for the following reasons: [1] that the water works utility is the property of the people within the city and is for their exclusive use; [2] that many of the people moved outside the city limits to avoid payment of municipal taxes and, therefore, should be denied benefits from those facilities which the city provides as a proprietary function; [3] that the availability of water service should be used as an instrument to in-

fluence the suburban communities to agree to annexation to the city; and [4] that the termination of a contract for water service between the city and a large suburban user, such as a water district, can work a hardship on the city because the user may become dissatisfied, make other arrangements for water service, and terminate his use of the city supply. This may leave the city with expanded production facilities and with insufficient revenues to pay for them.

The alternate policy must be based on the following philosophy: [1] that the interests of the city are common and integral with those of the suburbs, the city and its suburbs being interdependent for welfare and prosperity; [2] that the water utility is in business to sell water and should not refuse to sell to any potential customer; and [3] that the inhabitants of the suburbs should therefore be provided with water service by the city at a fair price for the service.

The source of supply may be remote from suburban consumers and close to the city, a condition which might create a moral obligation to serve. The demand of suburban consumers may even grow to exceed the demand within the corporate limits, or the local source of supply may become inadequate for the community, making it necessary to develop remote sources such as has been done in Southern California, with Los Angeles as the largest city. The common interest between the city and environs is accentuated in such a case, and the logical ultimate solution, for economic reasons, is the formation of a metropolitan water district. This condition, however, is obviously outside the scope of this paper.

Quite generally, the feeling about the obligation to serve suburban consumers

on the part of the city is mixed with resentment and resistance, but the usual result is that the service is furnished. The question then arises as to what controls, if any, or restrictions should the city exert over the suburban areas' distribution system improvements and extensions.

Control of Distribution System

Why should a city be interested in, or desire control over, the design and construction of a suburban water distribution system? The answer to this question may be resolved into contractual obligations, contingent or implied obligations, and possibility of annexation.

Most water utilities have adopted rules and regulations which pertain to the extension of mains to potential customers within the corporate limits. Therefore, if the city contracts to furnish service to single-family residences in the suburbs, the same policy relative to extensions can reasonably obtain. In this case the city will plan and install all improvements and will have full control of design, construction, and maintenance thereof. Likewise, the city assumes the responsibility to furnish service similar to that furnished urban consumers. Whether or not the obligation includes maintaining capacities and pressures adequate for fire protection will depend on policy. Usually the latter service is not furnished. The foregoing statements also apply where service is to be furnished to a suburban real-estate development. One of the outstanding features of dealing with a real-estate developer is that no effective contract can be entered into by the city because the developer is a comparatively irresponsible legal entity.

Contractual obligations to a water district, private water utility, or an incorporated community can, however, be established with greater effectiveness. Quite generally, service is contracted for at a master meter located at or near the corporate limits of the proprietary city. In this case, the city may contract to furnish water to the meter only in quantities and pressures available after supplying urban customers, furnish a certain maximum quantity to the meter at a specified minimum pressure, or furnish an unlimited quantity at reasonable service pressure to the consumers.

The latter contractual condition is obviously unrealistic, inasmuch as the proprietary city can have no definite or assured control over distribution system design in the suburban area served because the legal entity served normally designs, constructs, and owns the distribution system in the area and must provide booster pumps and system to furnish required operating pressures. This obligation would apparently ease the concern of the proprietary city. Such is not the case, however, because of the contingent or implied obligations. Experience indicates that the individual suburban consumer is inclined to blame the water department for all failures in service, in spite of the fact that the failure is a result of inadequate distribution facilities in the suburban area. Generally, the inhabitants of the area have business or other connections in the city and therefore can and do bring pressure to bear on the water department to rectify an impossible condition.

Suburban customers quite often become urban customers by annexation within a comparatively short time after

extensive development. When this occurs, the city assumes the responsibility of furnishing water service (including fire protection) to the new consumers. The city also is required to acquire or dispose of any privately owned water utility facilities in the area. This is usually accomplished by purchase.

In the light of the above conditions, it is rather obvious that the city should be very much concerned with the planning, design, and construction of suburban distribution systems. If no control is vested in the city, the water department will be unfairly blamed for low pressures, and will ultimately fall heir to a system of mains far too small for proper service and not properly planned to be a part of the entire city system. The acquisition cost will be high and the property acquired probably will be almost worthless.

Kansas City, Mo., is a perfect example for illustrating most of the conditions cited relative to suburban service. The area served covers parts of four different counties in Missouri and one county in Kansas. The consumers are served wholly or partly, directly or indirectly, by the Kansas City water utility. Outside of the city limits, distribution systems are generally owned by others. Suburban customers are a few large industries, privately owned utilities, water districts, and incorporated towns. Suburban areas have developed rapidly in recent years and recent annexation boundaries were established even during progress of this study. A definite need for control of suburban real-estate developments as to location and availability of water service has become apparent. Many such developments have been made in areas served by a water district which were

limited by contract to a totally inadequate supply of water from the city.

Financing Improvements

Fundamental policies on suburban main extensions were suggested in the 1949 progress report of an AWWA committee (1). According to this report, suburban policies should be non-discriminatory, be based upon business principles, assure that the extensions will be self-supporting, and provide for customer participation in the financing of extensions if the anticipated revenue is insufficient to warrant the utility's financing the extension unassisted. Obviously, these policies pertain to the case where the city proposes to serve individual suburban customers or to make an extension to a group thereof in a real-estate development. The following rules are therefore indicated to implement properly the stated policies:

1. Ownership of the suburban main extensions should be vested in the utility, even though others may assist in financing their construction.

2. The utility should have the right to make further extensions without incurring additional obligation to the original extension promoter.

3. The utility should determine the size of the pipe to be installed and insure that it is of sufficient size to yield proper fire flows and permit further extension, even though the promoter is charged only for a pipe of sufficient size to afford proper service in the immediate area traversed by the extension.

4. The city's investment in the extension should be limited to the amount resulting from capitalizing that portion of the gross revenue expected (calculated at urban rates) which represents depreciation plus "return" on distribu-

tion system investment. This amount (per customer) can be calculated from the formula:

$$X = \frac{ABD}{C}$$

where X is the allowable investment, A the percentage of gross revenue available for depreciation and return, B the percentage of total fixed capital in the utility represented by distribution system, C the annual allowance for depreciation plus return, both expressed as percentage of investment, and D the annual gross revenue, at urban rates, expected per customer.

The allowable amount of investment per customer will be the same, whether urban or suburban. The original investment may be made by the city. If a real-estate developer finances the extension, a refund is made by the city to the developer as customers are acquired. The foregoing policies and rules outlined apply impartially to both urban and suburban extensions. This does not imply, however, that rates or charges for water service should be the same.

Rates

The policy which should be adopted for determining rates to suburban consumers involves a matter of equity which, in turn, may become a matter of legal importance. In order to be legally defensible, water rates to suburban consumers must be fair and reasonable and must not discriminate between suburban customers.

When municipally owned water systems serve customers beyond the corporate limits, such customers will be fairly considered if the city acts as a private concern and applies the applicable legal principles for rates. These

principles consist essentially of the right of the city to earn a reasonable return on present investment which is in the property and which is useful in serving suburban customers. The rate of return from suburban customers, for instance, might be set arbitrarily at 6 per cent, although customers within the city may be charged rates which will yield a much lower average return. Rate schedules to wholesale suburban customers will most equitably consist of a demand charge plus a commodity charge in order to exercise cost control by the city over peak demands of the customer. Peak demands can be regulated to a considerable extent by the wholesale customer in his storage provisions.

The consideration of return on investment is consistent with common practice of regulatory commissions in the United States, tacitly approved by many court decisions. The principle has applied almost exclusively to privately owned utilities but is here submitted as being just as logically applicable to publicly owned utilities. Return is here defined as that part of the gross revenue received from a customer or group of customers, which is

over and above the cost of service. The detailed procedure for determining cost of service, chargeable to the respective groups or classes of customers, is not within the scope of this paper, but, in general, cost of service includes annual operating and maintenance expense, and annual depreciation allowance.

These two elements can be determined from properly kept accounts of the utility for a recent period and can be adjusted for known changes to a pro-forma basis representing a near future period. The third element, required to make up the balance of annual revenue needed or desired, should be in the nature of a return on investment. Each of these three elements can be allocated to the respective groups or classes of customers, or individual customers, in proportion to number of customers, quantity of consumption, and maximum demand, as indicated by the nature of the various items of cost.

Reference

1. COMMITTEE REPORT. Water Main Extension Policy. *Jour. AWWA*, 41:729 (Aug. 1949).



Distribution to Suburban Vancouver Areas

T. V. Berry

A paper presented on Apr. 18, 1955, at the Canadian Section Meeting, Quebec, Que., by T. V. Berry, Comr., Greater Vancouver Water Dist., Vancouver, B.C.

GREATER Vancouver is situated in the southwestern corner of the lower mainland of British Columbia. It is bounded on the south by the international boundary, on the east by the Pitt River, on the north by the Coast Range, and on the west by the Strait of Georgia.

Metropolitan Vancouver is about 20 miles wide and 35 miles long, comprising a land area of 563 sq. miles. Politically it is divided into five cities, ten municipalities, and two unorganized districts. As shown in Fig. 1, the metropolitan area is divided into four geographical sections by Burrard Inlet and the north arm and main channel of Fraser River. These sections and their land area are:

1. North Shore municipalities (99 sq. miles)—city of North Vancouver, and districts of North Vancouver and West Vancouver

2. Burrard Peninsula municipalities (146 sq. miles)—cities of Vancouver, New Westminster, Port Moody, and Port Coquitlam, municipality of Burnaby, and districts of Coquitlam, Fraser Mills, Maple Ridge, and Pitt Meadows.

3. Richmond (46 sq. miles)—Sea Island, Lulu Island, and several smaller islands

4. Municipalities of Surrey and Delta.

The annual rainfall in the area varies from 37 in. in the southerly portion of

Richmond, to 65 or 70 in. in the North Shore municipalities, differing from conditions in the watersheds farther north, where annual rainfall reaches 140–150 in. The average annual snowfall is 26.8 in. The average annual amount of sunshine in downtown Vancouver is 1,784 hr., and the mean annual temperature is 50°F, with a minimum recorded temperature of 2.3°F and a maximum of 92.2°F.

Background

Port Moody, at the head of Burrard Inlet, was originally selected to be the terminus of the Canadian Pacific Railway. The decision was later revoked, however, in favor of the growing settlement of Granville, which is now Vancouver.

The prime necessity of the growing city of Granville, or Vancouver, was an adequate water supply and, having anticipated that the final location of the Canadian Pacific Railway terminus would be at Vancouver, the Capilano River, on the north shore of Burrard Inlet, was chosen by local engineers as the best available water source for development as a permanent supply to the growing community. On May 23, 1887, just 13½ months after the new city had been incorporated by provincial act, the first passenger train from Montreal rolled into the new Van-

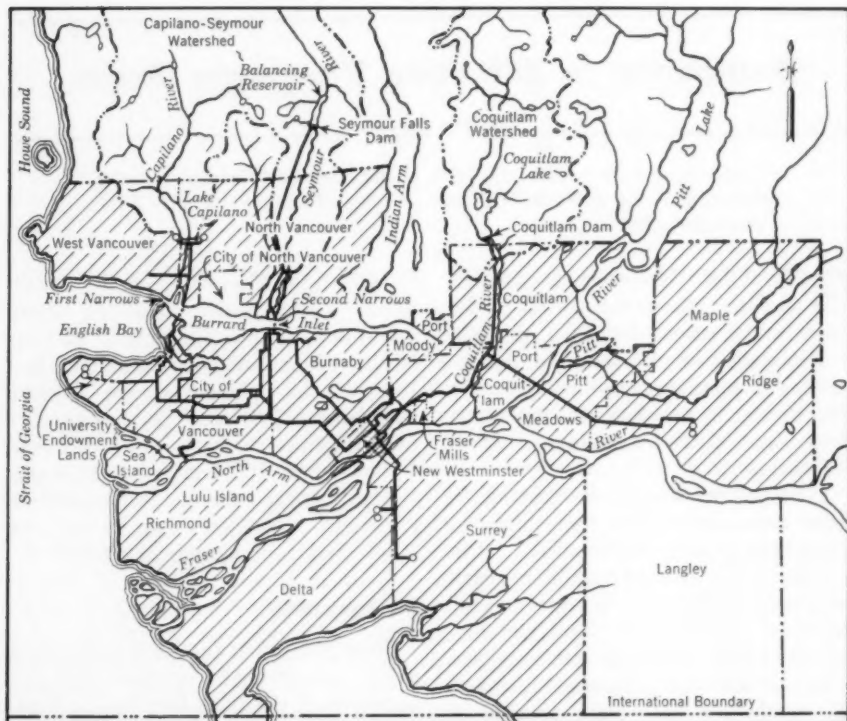


Fig. 1. Greater Vancouver Water District

The District, represented by the shaded portion of the map, comprises approximately 563 sq. miles. Storage tanks on the supply mains are indicated by O.

couver terminal and expansion of the community began.

A company composed of Victoria and Vancouver business men had been incorporated by act of the legislature on Apr. 16, 1886, the same day that Vancouver received its charter. This company, known as the Vancouver Waterworks Company, constructed the first water supply main from an intake on the Capilano River 7 miles upstream from Burrard Inlet. The main crossed Burrard Inlet at the First Narrows by submerged pipe and ended in the area

which is now Vancouver. The main, with a capacity of 4½ mgd, delivered its first water on Mar. 26, 1889. Vancouver purchased this system from the company in 1891.

As the city expanded during the following years, Vancouver added more capacity to the Capilano River supply with the construction of new supply mains, reservoirs, and another submerged crossing of the First Narrows.

In 1910-11, the city developed a second source of supply by constructing an intake and supply facilities on the Sey-

mour River, which lies east of and parallel to the Capilano River and empties also into Burrard Inlet at the Second Narrows (*see* Fig. 2). This supply was transported across the Second Narrows of Burrard Inlet into Vancouver by 18-in. diameter cast-iron submerged mains under the bed of the inlet. A portion of this supply was diverted to the municipality of Burnaby.

In 1886, at the time Vancouver was incorporated, the area, including Burnaby, the North Shore municipalities, the districts Vancouver, Coquitlam, and Port Moody, was timbered wilderness, except for scattered clearings along the waterfronts. Only New Westminster had reached any degree of maturity. As the adjacent districts gradually developed, water was required in larger quantities than could be obtained from wells, springs, or small local streams. It was not possible or economical for each young municipality to engage in construction of separate supply systems from Capilano or Seymour Rivers. The most logical solution for the districts on the south side of Burrard Inlet during those early years was to arrange for the city of Vancouver to supply the needed water from its relatively large and expanding systems.

The continued growth of Vancouver and the surrounding municipalities necessitated extensions of the various works. By about 1923, approximately 40 per cent of the population of the Burrard Peninsula (that portion of the area south of Burrard Inlet and north of the north arm of the Fraser River) was outside the city of Vancouver, and this fringe population was growing at a much faster rate than the population of the city. It can readily be understood, therefore, that this accelerated

growth both physically and financially taxed the ability of Vancouver to take care of the needs of the surrounding municipalities.

Repeated defeat of money bylaws, which were submitted for water works purposes over a period of years, made it impossible for officials to carry out well designed plans for the necessary extensions and increased supply to these municipalities. The failure of Vancouver to guard its own interests in so vital a matter as the conservation of the timber resources within the Capilano and Seymour watersheds was also of grave concern to those interested in the conservation of the water supply of the future metropolitan area. One can understand, therefore, the apprehension of those already large and still expanding communities satellite to Vancouver when they contemplated their position, for failure of the Vancouver citizens to ratify a money bylaw could retard the growth, prejudice the interests, and imperil the communal health of the new communities. Some form of joint control over the supply sources for the greater Vancouver area was necessary to ensure that the whole area would be in a position to obtain its water supply for all time on the most equitable terms. This implied that duplication of effort, expense, and waste of resources must be avoided and that no municipality in the area to be served should be required to finance the cost of development for any or all of the others.

Creation of Water District

The city of Vancouver, the municipalities of Point Grey, South Vancouver (which amalgamated with Vancouver in 1929 to form the present city of Vancouver as shown in Fig. 1), and

the municipality of Burnaby, had already had some experience with the metropolitan form of municipal organization. In 1914 the Vancouver and Districts Joint Sewerage and Drainage Board had been constituted with these four municipalities as its members. The corporation was responsible for the construction and operation of joint trunk sewers, drains, and outfalls for these four municipalities which occupy the Burrard Peninsula. After World War I, when these municipalities, under the pressure of increasing population and inadequate supply, began a movement for creating an organization that would be empowered to provide a water supply sufficient for the larger community which, it was felt, would emerge in future years on Burrard Inlet, it was natural that the provincial government, with the acquiescence of the municipalities concerned in the venture should create a metropolitan water district.

The Greater Vancouver Water District Act, which incorporated the District, was passed by the legislature of the province in December 1924. The District included the areas within the territorial limits of the city of Vancouver, the municipality of South Vancouver, and the municipality of Point Grey, all of which now comprise the city of Vancouver. Provision was made in the legislation for the subsequent addition of other municipalities from time to time.

Purposes and Terms

The objects of the District are stated in the Act as "the acquiring, supplying, and distributing of water from any source or sources for the use of inhabitants of the District for all pur-

poses, or for the use of adjacent areas outside the District, including any unorganized territory, or for any other purpose within or without the District. It shall be within the corporate authority of the corporation to extend its operations and to exercise its powers outside the limits of the District to any point or points within the Province where it deems it expedient so to do in the interest and business of the Corporation."

The Act provided that the District should purchase from Vancouver the water supply systems of the city, but not the distribution system. These supply systems included three intakes, two service reservoirs, and all appurtenant supply mains. The price to be paid by the District was the actual cost thereof to the city. That part of the purchase price represented by the total amount of the outstanding obligations in the nature of bonded indebtedness created in respect of the property purchased, and charged against the general credit of the city of Vancouver, was to be paid by the District, as the interest and installments of principal or sinking fund became due. The balance of the purchase price was to be paid in cash. Similar conditions were to apply to the purchase of the supply systems of any municipalities which were then within the District, including Point Grey and South Vancouver.

Provision was also made for taking a vote of the electors of the municipalities within the proposed District on the question of whether or not they were in favor of the creation of the District. This provision of the Act came into effect on the date of its passage. The remainder of the Act was to become effective by proclamation of the Lieutenant-Governor after an agreement fixing

the respective amounts and terms of purchase had been confirmed by the several municipalities and after the plebiscites had been taken and answered in the affirmative.

Certain amendments to the Act were made in the 1925 session of the legislature, and the Act was brought into effect by proclamation on Jan. 19, 1926. The organization of the District was immediately effected and it began its operations on Feb. 3, 1926. The annual amounts of sinking fund and interest assumed by the District on behalf of Vancouver at that time were: outstanding bonded indebtedness (including Point Grey, and with bonds maturing from 1927 to 1965), \$3,935,841.26; annual sinking fund payments, \$42,889.40; annual interest, \$175,201.62.

Membership and Representation

By later amendments, the Act now provides for the control of the District by an administration board consisting of representatives appointed annually by the respective municipal councils now or hereafter included in the District.

Each municipality other than the city of Vancouver appoints one representative, except for those municipalities which have agreed to share their representative. The number of Vancouver representatives comprises one representative more than half of the board membership. Each Vancouver representative has two votes, and each representative appointed by the other municipalities has one vote.

In 1955, distribution of representatives was such that fourteen cities and municipalities were represented by nine representatives with one vote each, and Vancouver was represented by five

representatives with two votes each. Thus, Vancouver had a majority vote of one on the administration board. This provision was made as a recognition of the preponderance of Vancouver's interest in the undertakings of the District. It should be noted that in the 29 years since the District's inception, only once has the dual voting of the Vancouver delegates been invoked, and on that occasion they did not vote unanimously.

Subject to the authority of the board, the undertakings of the corporation are under the management of a commission.

Briefly, the Act empowers the District:

1. To purchase, construct and operate water works systems and to enter on lands and streets for that purpose.
2. To acquire lands and timber within or without the District to be used for its water works or for protecting or preserving its sources of supply
3. To use powers of expropriation
4. To incur debts, and to pledge assets and credit of the District by borrowing money through the issue and sale of debentures and other securities of the District after having obtained the consent of the Lieutenant-Governor-in-Council
5. To add other municipalities to the District under such terms and conditions as may be mutually agreed upon.

Revenues

The revenues of the District are raised by sale of water. At the beginning of each year an estimate is made of the sum required for interest on borrowed money, for debt retirement, for maintenance, operation, and administration, and for necessary reserves. Due allowance is made for sale of wa-

ter to members outside the District. The rate to be charged for water to each municipality within the District is then fixed by the board on the recommendation of the commission. If it becomes apparent at any time during

required. The rate per 1,000 gal (Imp.) has steadily increased from 3.76¢ in 1926 to 9.04¢ in 1955. It can be seen that the District operates without profit, and its yearly revenues must equal the lawful expenditures.

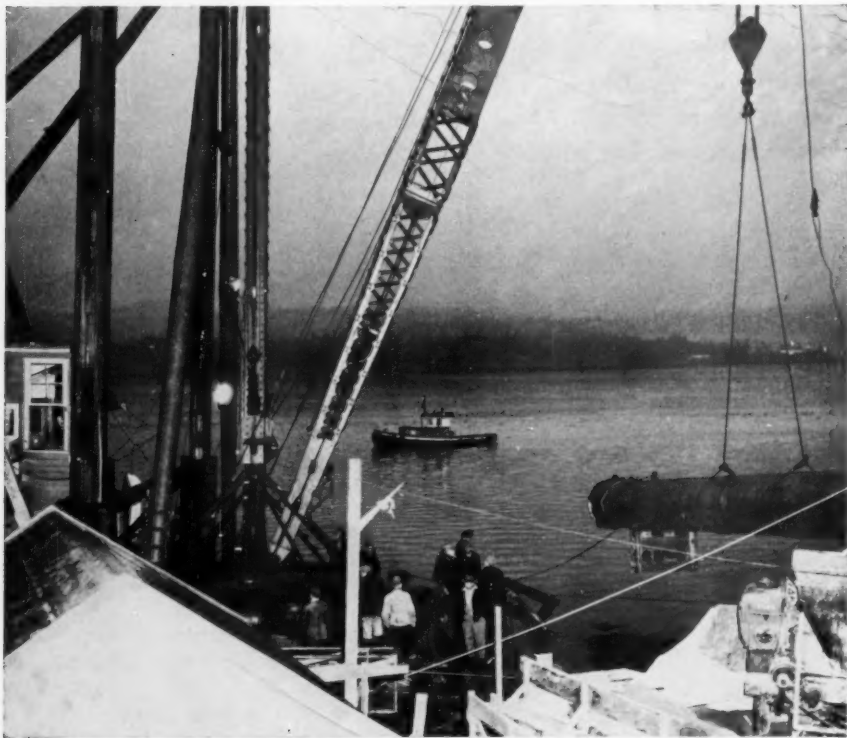


Fig. 2. Laying Submerged Pipe Across Second Narrows

When the second source of supply was developed by the District in 1910-11 the Second Narrows of Burrard Inlet were crossed with submerged 48-in. steel pipe.

the year, however, that the rates so fixed are higher or lower than are necessary to raise the required amount, the board revises and adjusts the rates either upward or downward so that the total amount collected for the year shall equal, as nearly as possible, the amount

The rates are a special charge or lien upon each municipality and the full taxing power thereof, and all the property and assets of the municipality within the District, and are recoverable at the suit of the corporation. The debts of the District and its debenture

obligations are a direct responsibility of the District and of each and every constituent municipality, both jointly and severally.

The Greater Vancouver Water District, then, was formed with water resources developed to a very limited degree, but with physical and financial resources sufficient to develop water supply that was adequate for the respective needs of all the municipalities occupying the lower mainland of the province and for the large metropolitan population that was expected to emerge.

The new District was soon faced with the necessity of formulating a policy governing the entry of new members into the organization. Extensions required to give the new members adequate service had to be financed, and the problem of welding the municipalities into a community in which the interest of the metropolitan organization was paramount to the local and parochial interests of the individual municipalities had to be solved.

New Extensions

When setting a policy for the financing of water extensions to communities remote from urban centers, it is probably sound economics to keep three principles in mind. These principles were well defined in a recent statement of policy relative to water main extension (1). The principles, briefly stated, are:

1. Extension rules should not favor new customers so greatly that extensions will increase or tend to increase the cost of water service to existing customers. (By having developed the water works plant and distribution through their water rate payments and contributions, the existing customers

have enabled the new members to obtain water at reasonable cost.)

2. New customers should be able to obtain water main extensions and water service at the lowest reasonable cost. The growth of the community should be encouraged by a fair extension policy but not by subsidization.

3. Revenue from new customers should generally exceed the cost of supplying water, including carrying charges on plant, general property, and the large mains used in the service. The utility's investment in a water main extended to serve a new customer should be based on the portion of the revenue available to cover carrying charges on such an investment.

These basic concepts appear to be equitable for everyone concerned. There may be other factors inherent in the problems of supplying rural areas, however, which do not entirely conform to the three principles laid down. These factors frequently demand the formulation of a special policy for each particular case.

At its creation, the Greater Vancouver Water District found itself an entity owning two supply systems on the north shore, which were tied to the Burrard Peninsula by submerged mains under the harbor, and a disorganized supply system of new and old mains leading to three reservoirs and several elevated storage tanks in the Burrard Peninsula area. Much of this installation was in very bad shape or was inadequate in capacity. The new District was not only saddled with a debt structure, which it was required to amortize until the last maturity of the relevant debentures in 1965 was met, but it also had to plan immediate replacements with modern facilities. It had to determine as quickly as possible

the future growth of the whole lower mainland and the ultimate demands for water, and at the same time determine, in chronological order, the program of development. Several years were taken up with this planning, and it became evident that a number of relatively expensive structures would be required over the ensuing 50 years.

storage dams on the Seymour and Capilano Rivers and of service reservoirs in the communities to be served, and the laying of many miles of supply mains.

The immense size and cost of these facilities indicated that their creation would be most advantageously utilized if all the communities in the lower



Fig. 3. Cleveland Dam at Lake Capilano

Lake Capilano, 7 miles upstream from Burrard Inlet, was the first source of supply developed by the District. Cleveland Dam is at the bottom of Lake Capilano.

In general, the essential facilities that had to be built over the years were permanent and safe crossings of the First and Second Narrows (see Fig. 2), storage reservoirs in the mountains north of Burrard Inlet to supplement the river flow in periods of low runoff (see Fig. 3 and 4), construction of

mainland were to use the resources and, over the years, share the cost. Every encouragement was therefore given to communities to join the metropolitan district, which sometimes meant that they must abandon their water licenses on the supply streams to the District and take part or all of

their water from District sources. The District, in turn, undertook to build facilities to give the new members an adequate supply at the wholesale rate set each year by the administration board.

In the development of communities adjacent to a large urban center, an ample and good water supply is only one of the phases of effective metropolitan planning. It has certainly been the experience in British Columbia that, where good water is supplied, industry will follow. If this concept is followed, subsidization may be partly condoned in favor of attracting industry and thereby assisting in the development of a balanced economy in the larger community.

It will be seen from the foregoing description of the events leading up to the formation of the Greater Vancouver Water District that the enabling legislation not only contemplated the addition of a number of communities to the District which it created, but made provision for the extension of its operations outside the existing District and gave the new corporation every facility in the enabling legislation to extend generous terms to new members. In the years that followed, therefore, a number of communities have been added to the District by agreement of the ratepayers in each community had been ascertained. These communities and their dates of membership in the District are: Burnaby, 1927; municipality of North Vancouver, 1927; West Vancouver, 1929; New Westminster and Port Coquitlam, districts of Richmond, Coquitlam, and Fraser Mills, 1931; municipalities of Maple Ridge and Pitt Meadows, 1948; Surrey, Delta, and Port Moody, 1950.

The two basic principles adopted by the District in its negotiations with communities seeking to take water from District sources were:

1. Only by joining the District could a community enjoy the basic wholesale rate for water set each year by the administration board. If it did not become a full member pursuant to an agreement, but purchased water as a nonmember, it was required to pay a surcharge of 20 per cent. (Today, Connaught Heights, a small unorganized community of 120 acres between Burnaby and New Westminster, pays 20 per cent above the basic rate. The University Endowment Lands, in which is situated the University of British Columbia campus, not being organized as a municipality and thereby not qualifying as a full member, also pays the 20 per cent surcharge.)

2. All members of the District, irrespective of their relative location to the sources of supply, pay the same basic rate for water, although there have been occasional resentments on the part of several municipalities close to the sources of supply because they feel they are entitled to better treatment than outlying areas. But there are good reasons for adhering to this rigid provision, and it is generally received with satisfaction. A little thought as to the difficulties which would develop should there be a differential rate for the various cities and territories served confirms this wisdom of strict adherence.

Metering Main Supply

All supplies are metered into the member municipalities at or near their boundaries through venturi meters, which are read weekly. Members are usually billed every 4 weeks.

TABLE 1
Analysis of Retail Rates Charged by Members *

Area Served	No. Services	No. Meters	Annual Flat Rates—\$	Metered Rates† ¢ per 100 cu ft
Members				
Vancouver	89,193	15,493	17-23	20-11
Burnaby	19,994	704	23	20-7
New Westminster	8,223	1,767	18	30-8
District of North Vancouver	6,784	299	18	10-7
District of West Vancouver	5,396	80	Domestic, 27.50 Stores and offices, 18	
Richmond	6,369	155	30‡	19-10
District of Coquitlam	3,382	3,382	20	1,600-3,000 cu ft: 20 3,100 cu ft or more: 15
Port Coquitlam	1,037	96	24	More than 1,000 cu ft: 20-10
Pitt Meadows	426	None	33	
Maple Ridge	2,533	50	30	1-1,500 cu ft: 22 1,500 cu ft or more: 21
Surrey	5,396	113	30	17-8
Delta	2,200	78	24‡	25-15
Port Moody	755	12	Domestic, 24 Commercial, 42	
District of Fraser Mills	103	None	Free	
Total	151,791	22,229		
Nonmembers				
University Endowment Lands	450	450	None	1-1,200 cu ft: 32 1,200 cu ft or more: 18-9
Connaught Heights	458	5	None	
Total	152,699	22,684		

* Conditions indicated are as of Mar. 1, 1955.

† Meter rentals are additional.

‡ Indicates a minimum rate.

The enabling legislation requires that "the supply of water for each municipality shall be delivered and taken from the main conduits or pipes of the corporation at the nearest convenient point to or within the limits of such municipality having due regard to the safety, efficiency, and convenience of the system as a whole." The municipalities

take their supplies at certain designated points, therefore, and commence their distribution system from there. Where District mains traverse a municipality to reach the boundaries of another, additional connections may be made at other mutually agreeable points. Where this occurs, the District owns the meters and charges the municipal-

ity rent therefor. As a matter of good operating practice the number of such supplementary connections is kept to a minimum.

Metering Customer Services

When fully developed, the three sources of supply controlled by the District will provide for a population of possibly 2,000,000 people, at the present use of water.

In general, it is accepted as a basic policy that metering is required in communities where water is relatively scarce, where pumping, filtration, or softening costs make delivery expensive, or where the per capita use is high (200 gpd) because of the nature of its industrial or other use. As none of these factors is in existence in the lower mainland communities, it has generally been considered undesirable to meter domestic services. Because ample supplies are available in the hills at a reasonable cost to the communities and with no pumping or treatment expense involved (except that of chlorination), it has seemed wiser to provide more supply mains and service reservoirs for the use of the community than to spend the money for installation, administration, and maintenance of meters. The number of meters used for customer service is only 14.9 per cent of all services.

Table 1 gives the number of metered services and the total of services in each of the communities taking water from District sources. It will be noted that the University Endowment Lands area is completely metered. During those periods of relatively high temperature experienced between May and September in the lower mainland, the demand and use by the University Endowment Lands for sprinkling and

irrigation is higher than the average for the District as a whole, despite the complete metering of the services. This condition was experienced also in the period just before Point Grey became a member of Vancouver in 1929. The municipality was completely metered and its per capita use in the summer of 1928 rose to 250 mgd. This demand was considerably in excess of the unmetered average for the rest of the District.

It should be pointed out that the responsibility for sprinkling regulations during summer months, if or when imposed lies with the member municipalities. Several of the municipalities impose a sprinkling ban during the summer, irrespective of weather conditions, partly from habit and partly from a misconception of their ability to save some money by doing so. Vancouver and Burnaby, however, apply sprinkling bans during extremely hot periods by allowing houses bearing odd numbers to irrigate gardens during odd days on the calendar and even numbers on even days. Because these municipalities take approximately 75 per cent of the water delivered, it has the effect of somewhat alleviating the peak demand on the supply mains and reservoirs during periods of high demand.

Table 1 also shows metered rates for domestic, commercial, and industrial use, and the varied charges made by the member municipalities for flat rates. The rate for water paid to the District last year was 9.06¢ per 1,000 gal (Imp.). The member municipalities, in addition to the cost of water purchased, must carry fixed charges, and operation, maintenance, and administration costs on their own distribution systems. To all accounts,

however, they make some profit on the utility.

Financial

To finance District undertakings, the board has power by bylaw to incur debts and to pledge the assets and credit of the corporation by borrowing money by means of the issue and sale

without the recommendation of the commissioner nor without the approval of the Lieutenant-Governor-in-Council of the province. Every debt incurred is a direct obligation and liability of the corporation and each and every municipality within the District, both jointly and severally. The debentures or securities of the District are deemed to be securities in which trustees may



Fig. 4. Coquitlam Lake and Screen House

Coquitlam Dam, constructed by the Vancouver Power Co. in 1913, has a maximum height of 100 ft, extreme width at base of 655 ft, and a length, including spillway, of 1,000 ft.

of debentures and other securities of the corporation. The debentures are not guaranteed by the province of British Columbia, but no issue of debentures or other securities may be made

lawfully invest trust funds. No indebtedness of the Corporation is included in the general debt of a member municipality for the purpose of determining its borrowing powers.

In case a municipality fails to pay the rates for water delivered to it within 30 days of the date upon which they become due and payable, the board, by resolution, may authorize the giving of a notice to the delinquent municipality that its account is overdue and thereupon all money collected by the municipality after receipt of such notice by way of charges for water supplied to its consumers shall, upon collection, be set apart by the municipality and kept in a separate trust account and shall be applied, in priority to all other uses, towards the payment of all indebtedness of the municipality to the corporation.

This provision has never been invoked, but it is considered by the investing institutions and public to be a feature which makes the investment in District securities an attractive and relatively safe one. Consequently, District securities have always been in demand and the water district has enjoyed low interest rates in the past few years.

Summary

At the time of its creation in 1926, the Greater Vancouver Water District was composed of three political communities: the city of Vancouver, the district of South Vancouver, and the district of Point Grey. The new District immediately found itself in possession of two excellent but undeveloped sources of supply on the north shore of the lower mainland area of greater Vancouver. Its general facilities were obsolete and inadequate, with the exception of a newly completed 36-in. supply main from Seymour In-take into Vancouver.

At that time, Vancouver was surrounded by cities and municipalities which were all growing rapidly and were anxious to obtain an adequate supply of water for their future needs. After preliminary studies it became evident that the new District would eventually require large capital expenditures to develop the water supply resources necessary for the large metropolitan area that was bound to emerge. The new District therefore invited the satellite municipalities into its orbit by using generous but reasonable terms. In this way, the municipalities were assured of a long-range program of development of the resources in which they would share, and the total cost to each was undoubtedly less than if they individually attempted to develop their own facilities.

In general, the principles underlying the negotiations and terms by which new municipalities became members were:

1. That the new member should assign certain facilities and water rights, to the metropolitan district which could better utilize them
2. That, as quickly as possible the District would provide facilities to take care of the new member's present and future water requirements at the "board rate"
3. That the new members would guarantee payment of certain fixed charges for a period of years, a portion of the revenue from water sales, in the meantime, being applied to these payments
4. That, where extensions were made, the cost of these should, as far as possible, not add materially to the service cost for the existing members of the District

5. That all members, irrespective of their location as to the source of the supply, would pay the same basic rate in any one year, and water supplied to nonmembers would carry a 20-per cent surcharge over the basic rate

6. That, where necessary and feasible, and without recompense, a member should permit the use of its mains for a limited number of years, or until other facilities can be constructed, for the delivery of water to another member

On Mar. 1, 1956, the District will have been operating for 30 years. In that time it has grown into a corporation with a membership of five cities

and nine municipalities, and it delivers water to approximately 600,000 people. With an enabling act well conceived and intelligently applied, and with successive administration boards truly metropolitan in their attitude toward the problems of the lower mainland, it is felt that, by a rational approach, the problems of suburban extensions have been efficiently met by the metropolitan organization.

Reference

1. WEIR, W. V., ET AL. Water Main Extension Policy. *Jour. AWWA*, 39:1067 (Nov. 1947).

AWWA Safety Manual Available

Safety Practice for Water Utilities, which was published as a series in the JOURNAL in July-December 1955, will be available as a separate Manual in March 1956. The 128-page paperbound book, including a useful table of contents and index, is priced at \$1.50. To members paying in advance, the price is \$1.20. Members ordering quantities of 25 or more will be charged at the rate of \$1.00 per copy.

Water Supply for Suburban Ottawa

—H. P. Stockwell—

A paper presented on Apr. 18, 1955, at the Canadian Section Meeting, Quebec, Que., by H. P. Stockwell, Deputy Comr. of Water Works, Ottawa, Ont.

FOR many years prior to 1950, Ottawa supplied water to adjacent communities through master meters located at the city boundaries. These areas included the town of Eastview, the village of Rockcliffe Park, the police villages of Hampton Park, Ottawa West and Westboro in Nepean Township, the Rockcliffe Airport, the National Research Council Montreal Road Laboratories, and the Rideau Health and Occupational Centre in Gloucester Township. In addition, the Overbrook Area and the new residential area of Manor Park, which were adjacent to Eastview but not to Ottawa, were supplied with city water taken through submeters from the Eastview system.

Following World War II, it became apparent that the supply to these communities and their adjacent open areas in the townships of Gloucester and Nepean would have to be greatly extended. These localities offered the necessary vacant land for badly needed new housing and large sections had already been expropriated by the federal government for the future relocation of Ottawa's railway system and for zoned industrial areas.

The existing water supply, storage, and feeder main installations of Ottawa were not sufficient to meet this expansion and the immediate and future capital outlays necessary to make them adequate were far greater than could reasonably be imposed upon water

consumers already sufficiently served. These costs were likewise far beyond the limit that the people in the new areas could support. The expected additional revenues from the new properties served would be small at first and would afford little relief for some years ahead. A partial solution to this difficulty was to be found, however, in the recommendation of the Joint Committee of the Senate and House of Commons, established in 1944 to review the special problems arising out of the location of the seat of government in Ottawa. The committee had reported the need for joint action on the part of the government and the city in planning and financing certain municipal projects.

Planning

The foremost problem was deciding in what way the Ottawa area was to be developed in keeping with its position as the nation's capital. To study and report on this, the federal government had, in 1946, appointed the National Capital Planning Committee, which was representative of all parts of Canada. It had also engaged Jacques Greber, eminent planning consultant of Paris, France, to prepare plans and to report on the development of the national capital and its surrounding area.

The Greber report, with its accompanying master plan, was completed in 1950. It outlined the proposed devel-

opment of streets and highways, designated land use, and proposed recommendations of an architectural and general town-planning nature, but it did not attempt to blueprint the development of the essential utility services. One important accomplishment of the Greber report, however, was the delineation of ultimate limits for the planned urban area with its surrounding green belt. Beyond these limits the water supply was not to extend, and for the first time, it became possible to design major water works installations without fear of future inadequacy arising from further expansion. The Greber report was followed by a companion master plan for the development of the major water and sewage works.

Meanwhile, the interested municipal authorities had established the Ottawa-Gloucester Expansion Committee to study expansion of Ottawa into Gloucester Township, and the Ottawa Planning Area Board, which tendered its report in December 1947. This report referred to the vast sums of money that would be spent by private individuals, companies, the municipalities, and the government of Canada in developing the urban area. It stressed that if this was to be accomplished in an orderly and progressive manner, without overlapping of expenditures and in accordance with a single plan, unified control for all the physical, social, and administrative services required by the urban population was absolutely essential. The Ottawa Planning Area Board also considered that the plan for the national capital could best be carried out if the federal government had a single municipal authority to deal with. It further suggested that, with such an arrangement, the

government would be less likely to enter the municipal field and secure some control of local government.

Unified control of most of the area concerned, except for the town of Eastview and the village of Rockcliffe Park, was brought about by the annexation, on Jan. 1, 1950, of large parts of the townships of Gloucester and Nepean, whereby the total land area of the city of Ottawa was increased from 5,199.8 acres to some 27,225.0 acres. This enclosed most of the ultimate urban area as defined by Greber and also included a small part of those sections designated as green belt. Unification of services was effected in this way rather than by the formation of an interurban administrative area because of the very special problems arising from the planning of a national capital and because unification of function and control would leave almost no direct authority to the various municipalities concerned. Present Ottawa and suburban areas are shown in Fig. 1.

On the date of annexation, Jan. 1, 1950, the amalgamated water works systems contained 245.91 miles of cast-iron mains installed over a period of 75 years. Since that date, another 82.68 miles have been installed and 38 additional miles were installed during the summer of 1955. This will represent a mileage increase of practically 50 per cent in a 6-year period. These figures do not include 8,706 ft of 24-in. steel-reinforced concrete pipe installed in 1954 to extend the supply westward, where considerable distribution main installation on intersecting streets will be carried out.

Expansion Program

To meet the impact of the new conditions upon both the financial and per-

sonnel resources of the water department, certain very radical changes had to be instituted.

The "local-improvement method" of financing new distribution mains was adopted. By this method a portion of the cost is distributed among the owners of abutting properties according to front footage. The city assumes the costs attributable to:

1. Street intersections
2. Hydrants and laterals
3. Pipe diameters over 6 in.
4. 50 per cent of the flanking of corner lots, not exceeding the cost for 60 ft
5. Frontage costs for abutting lands unfit for building
6. Frontage charges for lands owned by school boards which, although assessed against the land, are not collectible while so occupied. This applies also to frontage charges on lands owned by the Federal District Commission. When such commission properties must be passed by feeder mains required to serve new subdivisions, the developers are sometimes required in their agreement with the city to assume these costs. The frontage costs are amortized over a 15-year period but may be commuted in cash at the option of the owner. Developers of new subdivisions are required to pay \$3 in cash per foot of frontage (not including flanking of corner lots) towards the owners' share of these local improvement charges. This payment is part of the so-called "three, three, and two" formula, whereby such developers are required to pay a total of \$8 cash per foot frontage towards the owners' share of costs—\$3 for water mains, \$3 for sewers, and \$2 for roadways in the subdivisions concerned.

Because of the large number of petitions for new water mains, the city council has established a priority system whereby the local-improvement reports are prepared and forwarded in the order in which the petitions are filed with the city clerk. This very equitable procedure provides a buffer against the demands of those who would seek preferential treatment in this respect.

Installation of new water mains, including the actual pipelaying, has been turned over to contractors. The pipe, as well as valves, hydrants, and other material, is purchased by the city and supplied to the contractor at the location of the project. The only work now done by civic forces, aside from supervision and inspection, is the tapping of existing mains and the disinfection of the newly laid pipe. Because much of the new work is being carried out in areas served by individual septic tanks for sewage disposal, the disinfection of new mains is given added importance and is most carefully carried out.

To insure a minimum of faulty joints by the contractors, lead was discontinued as a jointing material and the pipe, valves, fittings, and hydrants now purchased for new installations are of the mechanical-joint type.

The cost of service connections has been transferred to the property owner. Previously, for a \$1 fee, the city would excavate and install a service connection from water main to property line. Under the new conditions, however, this would be far beyond the resources of the water department, and the work done by the city now consists of tapping the main and extending the service to the property line. The fee of

\$40 charged for a $\frac{5}{8}$ -in. service covers the cost of supplying and installing the required material. All excavation and backfilling on the street, and all work done on private property is handled by the owner or his contractor.

Very positive measures had to be undertaken for the elimination of waste, both under the streets and on private

take metering of all water consumption, including that in single residential property, has been carried out. An intensive study of installation time and materials used resulted in the design of a new meter setting which greatly speeded up the time required per installation with commensurate reduction in cost. In a period of 28 months,

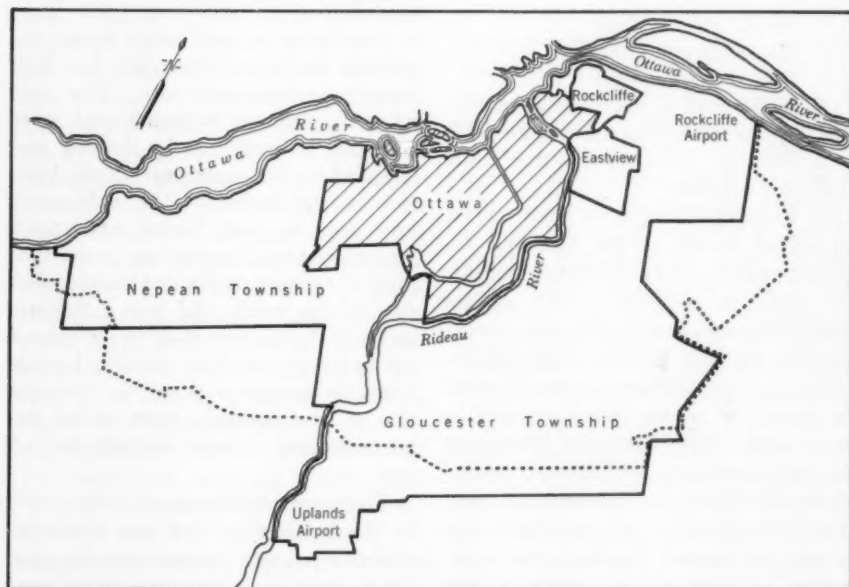


Fig. 1. Ottawa and Suburban Areas

The city of Ottawa, as it was before 1950, is indicated by the shaded area. Boundaries of the annexed areas are shown as heavy lines, and the dotted line indicates the ultimate limits of the planned urban area, as determined by the National Capital Planning Committee.

property. Annual waste-water surveys are made to locate any new underground leakage. Restriction of lawn sprinkling to scheduled hours and regulation of water used for air-conditioning equipment are also necessary measures and are strictly enforced. A recommendation that the city under-

starting in October 1952, district employees have installed 27,600 meters, mostly in residential properties. When using the new setting, the installers have often left the building within 15 min. Using this method the all-inclusive cost is less than \$5 per installation, plus cost of the meter (1).

Upon completion of the metering program, a new and more equitable system of water rates was adopted by the city council. The new rates separate the costs of providing water for fire protection from the costs of supplying water for commercial and residential use. The cost of water for fire protection is recovered from the individual owners in proportion to the assessed value of property protected. Costs of supplying water for commercial and industrial use is recovered on the basis of the measured volume taken rather than on that of property evaluation, as had been true in respect to residential property. Arrangements were made for water meter reading to be carried out jointly with electric meter reading by the Ottawa Hydro Electric Commission. A bimonthly reading cycle was adopted, the accounting and billing being carried out with a modern punched-card system.

Ottawa has adopted the policy that the water supply will be extended only as far as the city boundary or to the inside boundary of the green belt, whichever is closer to the source of supply. This assures that certain areas closer than the green belt but not annexed will not be supplied with city water in advance of city residents who are still unserved.

Federal Assistance

While the greater part of the cost of new projects is borne by the water department or the owners of abutting land, some assistance has been received from the federal government for certain specific projects.

One of these projects was a 16-in. water distribution main installed under the local improvement method to supply the eastern section of the Gloucester

area and, more particularly, to bring a supply to the National Research Council development on the Montreal Road. A 500,000-gal steel ground storage reservoir was constructed at the easterly end of this main. It was calculated that the NRC development would require about 40 per cent of the total flow. As this urgent government requirement forced construction of the main somewhat in advance of the normal probable date, a cash payment in the same proportion of 40 per cent of the total cost was made towards this installation. The government thus avoided the necessity of a privately installed feeder main to the location.

Major projects constructed in advance of normal need have also been assisted. In 1944 the Joint Committee of the Senate and House of Commons reported the necessity of governmental participation in the financing of certain municipal projects. In a speech in the Commons on Nov. 14, 1949, the Minister of Finance acknowledged the justice of the whole country's joining with the city of Ottawa in sharing the burden resulting from the plan for a national capital. Assistance has taken the form of federal government assumption of the debenture interest on borrowings incurred for works beyond the city's ordinary needs, for the period by which the construction is considered to be in advance of normal need or expectancy. Under this formula, the city is to receive interest at 3.7 per cent for a period of 8 years on the \$2,800,000 cost of the 24-mil gal reservoir and feeder main, and for 10 years on the \$210,000 cost of the 750,000-gal elevated storage tank built in the annexed section of Gloucester township and which is required to serve the new railway and industrial areas. Private-

land developers are required to pay similar interest payments on the estimated cost of the corporation's share of feeder water mains to their subdivisions if such can be considered in advance of normal expectancy.

Temporary Supplies

In some four or five localities in the annexed areas, beyond the periphery of the present city water system, housing developments have been carried out which are served by deep wells with central pumping. In such instances water mains have been installed according to water department specifications. For the present, the well water supply facilities are operated by the various developers concerned, but the distribution installations are such that they can be taken over and incorporated into the city system when the city supply is brought to them. These water areas seem to afford a reasonable

temporary supply, except that the supply available for fire protection is not up to city standards.

Summary

Ottawa is carrying out a greatly accelerated construction and expansion program to meet the problem posed by the development of the national capital. In the five years that have passed since the five-fold increase in the city area, new water mains installed have totalled some 82 miles and the annual requirement is still increasing. Major supply works are also being carried out in accordance with a master plan in which all features are in harmony with the ultimate requirements of the national capital's urban and suburban areas.

Reference

1. MACDONALD, W. E. Introduction of Universal Metering at Ottawa. *Jour. AWWA*, 45:909 (Sep. 1953).



Dilution of Fluosilicic Acid

—Ervin Bellack and F. J. Maier—

A contribution to the Journal by Ervin Bellack, Chemist, and F. J. Maier, San. Engr., both of Div. of Dental Public Health, U.S. Public Health Service, Bethesda, Md.

WHEN undiluted fluosilicic acid is fed directly into water to produce a concentration of approximately 1.0 ppm fluoride, no particular difficulties are encountered. When attempts have been made to use this acid at smaller plants, however, where limitations of the chemical feeders have required that the acid be diluted prior to feeding, considerable difficulties have been experienced. These difficulties have arisen when the acids are diluted in the order of more than ten parts of water to one of acid, resulting in the formation of a visible, insoluble precipitate which clogs the feeder and its appurtenances, valves, pumps, and orifices. The composition of this precipitate has been investigated and it was found to be finely divided silica.

The precipitate forms regardless of the nature of the water used for dilution of the acid, and distilled water causes it to form as readily as does water containing more than 2,000 ppm of dissolved solids. The amount of dilution is critical, however. Beyond a ratio of about twenty to one, when an acid containing the greatest silica content obtainable is used, no precipitate is formed. Not all of the commercially available acids exhibit this precipitate-forming characteristic, however.

Methods of Production

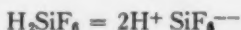
Two methods are used for producing this acid. The more common involves

the absorption by water of silicon tetrafluoride, produced by the acidification of phosphate rock. The fluosilicic acid produced by this process contains appreciable and varying amounts of free silica.

The other method is essentially a controlled reaction of silica in aqueous hydrofluoric acid, and the fluosilicic acid thus formed is of higher strength and, being practically free of colloidal silica, will not form a precipitate on dilution. Because this method is more expensive, however, most of the fluosilicic acid used for water fluoridation is produced by the former method, resulting in greater amounts of free silica.

Use of Hydrofluoric Acid

To prevent the formation of objectionable precipitate, it was thought possible either to stabilize the colloidal suspension or remove the excess silica by physical or chemical means. To this end, several additives were tried, but only strong acids gave any measure of success, and, of these, hydrofluoric acid seemed most promising. Hydrofluoric acid not only dissolves the colloidal silica, but is entirely compatible with the fluosilicic acid solution equilibria:



Conclusion

With the commercial acids available, the optimum ratio for the elimination of precipitation was found to be 0.2 ml of 48 per cent hydrofluoric acid to 10.0 ml of 30 per cent fluosilicic acid. The commercial fluosilicic acid could then be fortified on the basis of 1 gal of hydrofluoric acid to 50 gal of fluosilicic acid. The addition of this amount of hydrofluoric acid would alter the corrosive characteristics of the mix-

ture very little and the increased chemical and handling costs would be offset by the higher fluoride ion concentration in the resulting dilution. Optimum ratios for acids having different colloidal-silica concentrations would necessarily have to be determined by the acid manufacturers. In the interests of safety and maximum effectiveness, these manufacturers should also stabilize the acid at their plants by adding the optimum quantities of hydrofluoric acid.

Steel Tank Specifications Revised

Extensive revision of Standard Specifications for Steel Tanks, Standpipes, Reservoirs, and Elevated Tanks, for Water Storage—AWWA D100 was approved by the Board of Directors Jun. 7, 1955. The changes affect almost every section. In addition, an appendix on radiographic test procedures has been included. The designation for the revised specifications is D100-55, and they are priced at 80 cents per copy.

As in the past, the D100 booklet also contains the Tentative Recommended Practice for Painting and Repainting Steel Tanks, Standpipes, Reservoirs, and Elevated Tanks—AWWA D102. Several sections of the latter, dealing with wax coatings and their application, have likewise been revised, in accordance with Board approval on Aug. 5, 1955. The document has been redesignated D102-55T. (The revised D102 is also being printed in combination with the Recommended Practice for Inspecting and Repairing Steel Tanks, etc.—AWWA D101-53, which is unchanged. The price for this combination is 50 cents per copy.)

American Water Works Association

Tentative
STANDARD SPECIFICATIONS
for
METAL-SEATED BUTTERFLY VALVES

These "Specifications for Metal-seated Butterfly Valves" are based upon the best known experience. Torque requirements for operation increase rapidly with increase in velocity. In specifying valves to be purchased under these standards, care must be exercised by the responsible engineer to ascertain that operating conditions fall within the scope of the specifications.

Approved as "Tentative" Nov. 10, 1955

- Price of reprint—25¢ per copy
- Approximate date available—Apr. 15, 1956

AMERICAN WATER WORKS ASSOCIATION
Incorporated

521 Fifth Avenue, New York 17, N.Y.

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AWWA C505-55T

**Tentative Standard Specifications for
Metal-seated Butterfly Valves**

Sec. 1—Scope

1.1. These specifications include cast-iron and steel, flanged-end, bell end, and mechanical-joint end metal-seated butterfly valves 3-72 in. in size, for maximum shutoff pressures and line velocities as indicated in Table 1, together with torque requirements for operation. The valves specified are suitable for frequent operation, operation after long periods of idleness, and operation in a throttled position in water lines.

1.2. These specifications cover valves designed for the shutoff pressure indicated in Table 1. Valves in each class shall be designed for opening and closing against the shutoff pressure specified with pipeline velocities not exceeding the velocity specified for each class. (Pipeline velocity is defined as water flow, in cubic feet per second, divided by internal area of pipe in square feet.)

Sec. 2—Information to Be Supplied by Purchaser

In placing orders for valves to be manufactured in accordance with these specifications, purchasers should specify the following details:

2.1. Designation of AWWA specifications applying.

2.2. Size of valve.

2.3. Class of valve.

2.4. Kind of end—flanged, bell, or mechanical joint.

2.5. Quantity required.

2.6. Whether records of tests are to be furnished as specified under Sec. 5.3 of these specifications.

2.7. Type of operation required; that is, electric motor, air cylinder, water cylinder, oil cylinder, or manual. If electric operation, power characteristics for motor; if cylinder operation, medium available (air, water, or oil) and minimum and maximum pressure available for cylinder actuation.

2.8. Time of operation (unless otherwise specified, power-operated valves shall operate from full-open to full-closed position, or vice versa, in approximately 60 sec).

Sec. 3—Data to Be Furnished by Bidder

3.1. The bidder shall furnish certified drawings and material specifications of the equipment he is proposing to supply. The drawings shall show valve port diameter and shall be in sufficient detail to show that the equipment proposed meets the specifications of the purchaser.

3.2. When required, the bidder shall furnish a statement of the total net assembled weight for each valve.

Sec. 4—Data to Be Furnished by Manufacturer

4.1. When required, the manufacturer shall submit, for approval by the purchaser, three sets of certified drawings showing the principal dimensions, general construction, and materials used for all parts of the valve. All work shall be done and all valves shall be furnished in accordance with these certified drawings after they have been approved by the purchaser.

4.2. The manufacturer shall furnish certification of tests, if required.

Sec. 5—Materials

5.1. *General.* All materials designated hereinafter, when used in valves

produced under these specifications, shall conform to the specifications designated below for each material listed. When reference is made to American Standards Assn. (ASA), American Society for Testing Materials (ASTM),

TABLE 1
Classes of Valves

Sizes in.	Velocity— <i>fps</i>				Free Discharge	Shutoff Pressure <i>psi</i>
	16	25	35	60		
	Class					
24-72	M-25-16	M-25-25	M-25-35		M-25-F	25
24-72	M-50-16	M-50-25	M-50-35		M-50-F	50
3-72	M-100-16	M-100-25	M-100-35	M-100-60	M-100-F	100
3-72	M-150-16	M-150-25	M-150-35	M-150-60	M-150-F	150
3-24	M-200-16	M-200-25	M-200-35	M-200-60	M-200-F	200

TABLE 2
Valve Body Length

Valve Size in.	Flanged—Face to Face—in.			Bell End or Mechanical Joint— Overall Length—in.	
	Class of Valve				
	25 psi	50,* 100 & 150 psi	200 psi	25 psi	50, 100 & 150 psi
3		5½	6		10½
4		6	7		12
6		7	8		13
8		8	10		13¾
10		9	11		14½
12		10	13		15½
14		12	15		17¼
16		13	16		18
18		14	17		19
20		16	19		20½
24	13	18	21	17	22
30	15	21		20	26
36	17	25		21	29
42	19	28		24	33
48	21	31		25½	35½
54	23	35		28	40
60	26	39		31	44
66	27	42			
72	29	44			

* 50 psi applies only to sizes 24 in. and larger.

and other specifications as may be stipulated, the latest revision thereof shall apply.

5.2. *Physical and chemical properties.* The requirements of ASA, ASTM, or other specifications to which reference is made elsewhere in this text shall govern the physical and chemical characteristics of the valve components.

5.3. *Tests.* Whenever valve components are to be made in conformance with ASA, ASTM, or other specifications that include test requirements or testing procedures, such requirements or procedures shall be met by the valve manufacturer. The records of such tests shall, if required by the purchaser, be made available to him.

Sec. 6—Valve Bodies

6.1. Bodies of all valves shall have two hubs for shaft bearings, integral with the valve bodies.

6.2. Valves specified with flanged ends shall have a drilling layout and flange thickness in accordance with the following:

Valve Class psi	Drilling Layout Specification
25, 50, 100, 150	ASA B16.1 (125-psi cast-iron fittings)
200	ASA B16b (250-psi cast-iron fittings)

All flanges shall have full-drilled holes.

6.3. Valves specified with bell ends shall have bells in accordance with AWWA Specifications C100.

6.4. Valves specified with mechanical-joint ends shall have ends in accordance with ASA A21.11 (AWWA C111).

6.5. Valves shall have face-to-face dimensions as specified in Table 2.

6.6. Minimum body thickness shall be in accordance with Table 3.

6.7. Unless otherwise specifically requested by the purchaser, bodies of all valves shall be of either cast iron (ASTM A126, Class B) or cast steel (ASTM A27).

Sec. 7—Valve Shafts

7.1. All valve shafts shall be of a one-piece unit extending completely through the valve disc.

TABLE 3
Minimum Body Shell Thickness

Valve Size in.	Thickness—in.		
	Class of Valve		
	25 psi	50,* 100 & 150 psi	200 psi
3		$\frac{3}{8}$	$\frac{3}{8}$
4		$\frac{3}{8}$	$\frac{3}{8}$
6		$\frac{3}{8}$	$\frac{3}{8}$
8		$\frac{3}{8}$	1
10		$\frac{3}{8}$	1
12		$\frac{3}{8}$	1
14		$\frac{3}{8}$	1 $\frac{1}{4}$
16		1	1 $\frac{1}{4}$
18		1 $\frac{1}{8}$	1 $\frac{1}{2}$
20		1 $\frac{1}{8}$	1 $\frac{1}{2}$
24	$\frac{3}{4}$	1 $\frac{1}{8}$	1 $\frac{1}{2}$
30	1	1 $\frac{1}{8}$	
36	1	1 $\frac{3}{8}$	
42	1 $\frac{1}{8}$	1 $\frac{7}{8}$	
48	1 $\frac{1}{8}$	2	
54	1 $\frac{1}{2}$	2 $\frac{1}{8}$	
60	1 $\frac{1}{2}$	2 $\frac{1}{2}$	
66	1 $\frac{1}{2}$	2 $\frac{1}{2}$	
72	1 $\frac{1}{2}$	2 $\frac{1}{2}$	

* 50 psi applies only to sizes 24 in. and larger.

7.2. All valve shafts shall have a minimum diameter extending through the valve bearings and into the valve disc, as specified in Table 4.

7.3. The valve shafts shall be securely attached to the valve disc by means of keys, dowel pins, taper pins, or any combination of the three. The connection between the shaft and disc

TABLE 4
Minimum Shaft Diameter

Valve Diameter in.	Shaft Diameter—in.				
	25-psi Valves				
	M-25-16	M-25-25	M-25-35	M-25-F	
24	2 $\frac{1}{4}$	2 $\frac{1}{2}$	2 $\frac{3}{4}$	3	
30	2 $\frac{3}{4}$	3	3 $\frac{1}{2}$	3 $\frac{3}{4}$	
36	3 $\frac{1}{2}$	3 $\frac{5}{8}$	4 $\frac{1}{8}$	4 $\frac{1}{2}$	
42	3 $\frac{3}{4}$	4 $\frac{1}{4}$	4 $\frac{7}{8}$	5 $\frac{1}{4}$	
48	4 $\frac{1}{4}$	5	5 $\frac{1}{2}$	6	
54	4 $\frac{7}{8}$	5 $\frac{1}{2}$	6 $\frac{1}{4}$	6 $\frac{3}{4}$	
60	5 $\frac{1}{4}$	6	7	7 $\frac{1}{2}$	
66	6	6 $\frac{3}{4}$	7 $\frac{1}{4}$	8	
72	6 $\frac{1}{2}$	7 $\frac{1}{4}$	8 $\frac{1}{2}$	9	
	50-psi Valves				
	M-50-16	M-50-25	M-50-35	M-50-F	
24	2 $\frac{1}{2}$	2 $\frac{7}{8}$	3 $\frac{1}{8}$	4	
30	3	3 $\frac{1}{2}$	3 $\frac{3}{4}$	5	
36	3 $\frac{5}{8}$	4 $\frac{1}{4}$	4 $\frac{5}{8}$	5 $\frac{1}{4}$	
42	4 $\frac{1}{4}$	5	5 $\frac{1}{2}$	6 $\frac{1}{8}$	
48	4 $\frac{7}{8}$	5 $\frac{5}{8}$	6 $\frac{1}{4}$	7 $\frac{1}{4}$	
54	5 $\frac{1}{4}$	6 $\frac{3}{8}$	7	8 $\frac{1}{4}$	
60	6	7	7 $\frac{3}{4}$	9 $\frac{1}{2}$	
66	6 $\frac{3}{4}$	7 $\frac{3}{4}$	8 $\frac{1}{2}$	10 $\frac{1}{2}$	
72	7 $\frac{1}{2}$	8 $\frac{1}{2}$	10	11 $\frac{1}{2}$	
	100-psi Valves				
	M-100-16	M-100-25	M-100-35	M-100-60	M-100-F
3	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{5}{8}$
4	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{3}{4}$
6	1	1	1	1	1 $\frac{1}{4}$
8	1 $\frac{1}{8}$	1 $\frac{1}{8}$	1 $\frac{1}{4}$	1 $\frac{1}{8}$	1 $\frac{1}{4}$
10	1 $\frac{1}{4}$	1 $\frac{1}{4}$	1 $\frac{1}{2}$	1 $\frac{1}{4}$	2
12	1 $\frac{1}{2}$	1 $\frac{3}{8}$	1 $\frac{3}{4}$	2 $\frac{1}{4}$	2 $\frac{1}{4}$
14	1 $\frac{3}{4}$	2	2 $\frac{1}{4}$	2 $\frac{1}{2}$	2 $\frac{3}{4}$
16	2	2 $\frac{1}{4}$	2 $\frac{1}{2}$	2 $\frac{3}{4}$	3 $\frac{1}{4}$
18	2 $\frac{1}{4}$	2 $\frac{1}{2}$	2 $\frac{3}{4}$	3 $\frac{1}{4}$	3 $\frac{3}{4}$
20	2 $\frac{3}{4}$	2 $\frac{3}{4}$	3	3 $\frac{3}{4}$	4
24	3	3 $\frac{3}{8}$	3 $\frac{3}{4}$	4 $\frac{1}{4}$	5
30	3 $\frac{3}{4}$	4	4 $\frac{3}{8}$	5 $\frac{1}{4}$	6
36	4 $\frac{1}{4}$	5	5 $\frac{1}{2}$	6 $\frac{1}{4}$	7 $\frac{1}{4}$
42	5 $\frac{1}{4}$	5 $\frac{3}{4}$	6 $\frac{1}{2}$	7 $\frac{1}{2}$	8 $\frac{1}{2}$
48	6	6 $\frac{3}{4}$	7 $\frac{1}{2}$	8 $\frac{1}{4}$	9 $\frac{3}{4}$
54	6 $\frac{3}{4}$	7 $\frac{1}{2}$	8 $\frac{1}{4}$	9 $\frac{1}{2}$	11
60	7 $\frac{1}{4}$	8 $\frac{3}{8}$	9 $\frac{1}{8}$	10 $\frac{3}{4}$	12 $\frac{1}{4}$
66	8 $\frac{1}{4}$	9	10	11 $\frac{1}{2}$	13 $\frac{1}{4}$
72	9	10	11	13	15

TABLE 4 (contd.)—Minimum Shaft Diameter

Valve Diameter in.	Shaft Diameter—in.				
	150-psi Valves				
	M-150-16	M-150-25	M-150-35	M-150-60	M-150-F
3	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{5}{8}$	1
4	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{7}{8}$	1
6	1	1	1	1 $\frac{1}{2}$	1 $\frac{1}{2}$
8	1 $\frac{1}{8}$	1 $\frac{1}{4}$	1 $\frac{1}{8}$	1 $\frac{3}{8}$	2
10	1 $\frac{1}{2}$	1 $\frac{3}{8}$	1 $\frac{1}{2}$	2	2 $\frac{1}{2}$
12	1 $\frac{3}{4}$	1 $\frac{7}{8}$	2	2 $\frac{1}{2}$	2 $\frac{3}{4}$
14	2	2 $\frac{1}{4}$	2 $\frac{1}{2}$	2 $\frac{3}{4}$	3 $\frac{1}{2}$
16	2 $\frac{1}{2}$	2 $\frac{3}{8}$	2 $\frac{3}{4}$	3 $\frac{1}{4}$	3 $\frac{3}{4}$
18	2 $\frac{3}{4}$	2 $\frac{7}{8}$	3	3 $\frac{1}{2}$	4
20	2 $\frac{7}{8}$	3 $\frac{1}{4}$	3 $\frac{1}{2}$	3 $\frac{3}{4}$	4 $\frac{1}{2}$
24	3 $\frac{1}{2}$	3 $\frac{3}{4}$	4 $\frac{1}{4}$	4 $\frac{1}{2}$	5 $\frac{1}{2}$
30	4	4 $\frac{1}{4}$	5 $\frac{1}{4}$	5 $\frac{1}{2}$	7
36	5	5 $\frac{1}{4}$	6 $\frac{1}{4}$	7	8 $\frac{1}{2}$
42	5 $\frac{3}{4}$	6 $\frac{1}{8}$	7 $\frac{1}{4}$	8	9 $\frac{1}{4}$
48	6 $\frac{3}{4}$	7 $\frac{1}{8}$	8 $\frac{1}{4}$	9 $\frac{1}{4}$	11
54	7 $\frac{1}{2}$	8 $\frac{1}{4}$	9 $\frac{1}{2}$	10 $\frac{1}{2}$	12 $\frac{1}{2}$
60	8 $\frac{1}{2}$	9 $\frac{1}{2}$	10 $\frac{3}{4}$	11 $\frac{1}{2}$	14
66	9	10 $\frac{1}{2}$	11 $\frac{1}{2}$	12 $\frac{1}{2}$	15 $\frac{1}{2}$
72	10	11 $\frac{1}{2}$	12 $\frac{1}{4}$	14	16 $\frac{1}{2}$
	200-psi Valves				
	M-200-16	M-200-25	M-200-35	M-200-60	M-200-F
3	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{3}{4}$	1
4	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{7}{8}$	1
6	1	1 $\frac{1}{8}$	1 $\frac{1}{4}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$
8	1 $\frac{1}{8}$	1 $\frac{1}{4}$	1 $\frac{1}{8}$	1 $\frac{3}{8}$	2
10	1 $\frac{1}{2}$	1 $\frac{3}{4}$	1 $\frac{1}{2}$	2 $\frac{1}{4}$	2 $\frac{1}{2}$
12	1 $\frac{3}{4}$	2	2 $\frac{1}{4}$	2 $\frac{1}{2}$	3
14	2	2 $\frac{1}{4}$	2 $\frac{3}{8}$	3	3 $\frac{1}{2}$
16	2 $\frac{1}{2}$	2 $\frac{7}{8}$	3	3 $\frac{1}{8}$	4 $\frac{1}{4}$
18	2 $\frac{3}{4}$	3 $\frac{1}{4}$	3 $\frac{1}{8}$	3 $\frac{3}{4}$	4 $\frac{1}{2}$
20	3 $\frac{1}{4}$	3 $\frac{1}{2}$	3 $\frac{3}{4}$	4 $\frac{1}{4}$	5
24	3 $\frac{3}{4}$	4 $\frac{1}{4}$	4 $\frac{1}{2}$	5	6

shall be designed to transmit shaft torque equivalent to at least 75 per cent of the torsional strength of the minimum required shaft diameters. Dowel pins and taper pins shall be mechanically secured.

7.4. Valve shafts shall be full size for the portion of the shaft that extends through the valve bearings, valve disc, and valve stuffing box and packing gland. In the event that the valve

shaft is turned down to fit connections to the valve operating mechanism, or to allow the application of bronze covering over the bearing and packing gland areas, the turned-down portion shall have ample fillets to minimize the possibility of stress concentration at the junction of the two different diameters. The turned-down portion of the shaft shall be capable of transmitting torque equivalent to at least 75

TABLE 5
Minimum Operator Torque for Most Adverse Conditions*

Valve Diameter in.	Minimum Torque—ft-lb				
	25-psi Valves				
	M-25-16	M-25-25	M-25-35	M-25-F	
24	1,370*	2,049*	3,100*	3,800	
30	2,685*	3,970*	6,000*	7,385	
36	4,580*	6,880*	10,390*	12,800	
42	7,300*	10,980*	16,560*	20,400	
48	10,900*	18,940*	24,580*	30,320	
54	15,600*	23,170*	35,000*	43,000	
60	21,400*	31,800*	48,000*	59,500	
66	28,400*	43,200*	64,400*	79,100	
72	36,600*	54,950*	83,150*	102,500	
	50-psi Valves				
	M-50-16	M-50-25	M-50-35	M-50-F	
24	1,810	3,175*	4,235*	7,820	
30	3,500	6,160*	8,270*	15,200	
36	6,150	10,670*	14,250*	26,270	
42	9,680	17,000*	22,860*	41,800	
48	14,250*	25,280*	34,000*	62,000	
54	20,800*	35,970*	48,100*	83,300	
60	28,500*	49,300*	66,400*	121,800	
66	37,900*	65,800*	88,500*	162,400	
72	48,800*	85,500*	116,000*	210,000	
	100-psi Valves				
	M-100-16	M-100-25	M-100-35	M-100-60	M-100-F
3	14	18	27	30	52
4	28	34	50	55	96
6	65	82	108	166*	250
8	141	181	251*	388*	590
10	269	362	485*	758*	1,170
12	452	603*	845*	1,310*	1,980
14	720	975*	1,135*	2,090*	3,140
16	1,070	1,445*	2,000*	3,150*	4,625
18	1,530	2,055*	2,840*	4,450*	6,460
20	2,095	2,810*	3,880*	6,040*	9,320
24	3,610	4,860*	6,765*	10,620*	16,150
30	7,030	9,450*	13,150*	20,640*	31,300
36	12,210	16,400*	22,670*	35,380*	54,150
42	19,390	26,000*	36,150*	56,400*	86,200
48	28,900	38,950*	53,800*	83,900*	129,300
54	41,200	55,300*	76,400*	119,700*	182,500
60	56,500	76,100*	104,800*	165,300*	252,200
66	77,200	90,800*	139,900*	220,800*	335,000
72	97,700	131,200*	181,700*	285,100*	437,000

* For the less adverse condition of opening against the full design pressure and velocity as specified for each class into a flooded system downstream, operator torques marked by an asterisk (*) can be appreciably reduced. When operating conditions (pressures or velocities) fall between the classes specified, an adjustment may be made in the torque values.

TABLE 5 (contd.)—Minimum Operator Torque for Most Adverse Conditions*

Valve Diameter in.	Minimum Torque—ft-lb				
	150-psi Valves				
	M-150-16	M-150-25	M-150-35	M-150-60	M-150-F
3	16	20	30	35	60
4	35	50	60	64	116
6	93	109	138	220*	400
8	208	252	331	518*	930
10	414	501	633	984*	1,800
12	709	851*	1,104*	1,722*	3,020
14	1,120	1,370*	1,760*	2,733*	4,900
16	1,660	2,015*	2,645*	4,060*	7,100
18	2,360	2,900*	3,730*	5,770*	9,200
20	3,200	3,940*	5,190*	8,030*	14,200
24	5,670	6,800*	9,900*	14,930*	24,700
30	9,820	13,350*	17,350*	26,900*	47,960
36	18,700	21,900*	29,950*	46,500*	83,000
42	29,600	36,500*	47,550*	73,300*	132,000
48	44,600	54,800*	71,300*	110,600*	196,000
54	63,300	78,600*	101,700*	156,700*	279,800
60	87,500	105,700*	139,400*	215,100*	385,600
66	114,500	143,100*	185,000*	286,000*	514,200
72	150,000	185,000*	239,700*	369,000*	663,000
	200-psi Valves				
	M-200-16	M-200-25	M-200-35	M-200-60	M-200-F
3	20	25	35	40	70
4	50	60	70	78	160
6	125	144	178	268*	520
8	274	872	398*	625*	1,250
10	545	650	781*	1,236*	2,430
12	937	1,095*	1,345*	2,143*	4,140
14	1,480	1,800*	2,135*	3,422*	6,680
16	2,290	2,680*	3,185*	5,060*	9,780
18	3,230	3,770*	4,535*	7,170*	13,980
20	4,460	5,200*	6,220*	9,860*	19,300
24	7,720	9,000*	10,600*	17,150*	33,000

* For the less adverse condition of opening against the full design pressure and velocity as specified for each class into a flooded system downstream, operator torques marked by an asterisk (*) can be appreciably reduced. When operating conditions (pressures or velocities) fall between the classes specified, an adjustment may be made in the torque values.

per cent of the torsional strength of the minimum required shaft diameter.

7.5. All valve shafts shall be 18-8 stainless steel, Type 302, 303, 304, or 316, or forged steel with a minimum thickness of $\frac{1}{2}$ in. of bronze (ASTM B22, ASTM B143, SAE 791) cover-

ing the shaft in the area of the bearings and packing glands.

Sec. 8—Valve Discs

8.1. Valve discs shall be of a cast or fabricated design with no external ribs. The design shall be such as to

sustain full differential pressures across a closed valve disc without exceeding a working stress of one-fifth of the tensile strength of the material used. The minimum thickness through the center of the valve disc for valves designed for a velocity of 16 fps or less shall be $1\frac{1}{4}$ times the shaft diameter. For classes in which the velocity is greater than 16 fps, the minimum thickness at the center of the disc shall be increased over that specified for the 16-fps class by the difference in shaft diameters of the respective classes. Discs shall be provided with drain holes on one face to prevent damage from freezing.

8.2. Valve discs shall be of cast iron (ASTM A48, Class 40), cast steel (ASTM A27), fabricated steel (ASTM A7), cast bronze (ASTM B61 or ASTM B143) or alloy cast iron (Military Specifications MIL-G-858a, Class I). Valve discs of cast iron (ASTM A48, Class 40), cast steel, or fabricated steel shall have seating edges of 18-8 stainless steel, Monel, or bronze (ASTM B132 or SAE 791) covering the full width of the disc seating edge. Sprayed-metal seats are not acceptable. Welded seats shall be at least $\frac{3}{32}$ in. thick.

8.3. In no event shall stainless-steel seats be used on discs in valves that have bronze seats in the valve body.

Sec. 9—Valve Seats

9.1. Valve seats shall be rigidly attached to the valve body and shall be smoothly and accurately machined for the seating of the valve disc. The valve body shall be machined through its entire inner surface, with the valve seat raised not more than $\frac{1}{4}$ in. above the inside surface of the valve body. Sprayed-metal seats are not acceptable.

9.2. Valves with discs that seat at an angle or at 90 deg to the pipe axis

are acceptable; both types, however, shall be provided with adjustable mechanical stops to prevent overtravel of the valve disc in the open and closed position. The mechanical stops shall be designed to absorb the full operator torque with a minimum design safety factor of five.

9.3. Valve seats shall be of bronze (ASTM B98, Alloy A), Babbitt (ASTM B23, Alloy Grade 12), or Monel No. 60.

Sec. 10—Valve Bearings

10.1. Valves shall be fitted with sleeve type bearings contained in the hubs of the valve body. Bearings shall be designed for a pressure not exceeding 2,500 psi.

10.2. If a shaft is designed for connection to an operator, a bearing shall be provided beyond the stuffing box gland. The housing for this bearing shall be rigidly attached to the valve body. If the operator is furnished as part of the valve assembly, the bearing may be fitted into the valve operator housing, which, in turn, shall be rigidly attached to the valve body.

10.3. Each valve shall be equipped with either one or two thrust bearings set to hold the valve disc securely in the center of the valve seat.

10.4. Sleeve bearings and other bearings fitted into the valve body proper shall be of "self-lubricated" materials which do not have a harmful effect on water and which do not have a coefficient of friction in excess of 0.25 when run at the specified maximum bearing pressure on material having a finish equivalent to that used on the valve shafting; or shall be of bronze with a simple means of adequately lubricating the bearing surfaces. The bearing beyond the stuffing box gland may be of "self-lubricated"

material, of bronze with a simple means of adequately lubricating the bearing surfaces, or of the "ball" or "roller" type.

Sec. 11—Stuffing Boxes

11.1. Where shafts project through the valve bodies for operator connection, stuffing boxes shall be provided. The design of the valve and stuffing box assembly shall be such that the packing can be adjusted or completely replaced without removing any part of the valve or operator assembly, and

to US Navy Dept. Specification 33-P-26-b, Type A, or of flax packing conforming to Federal Specification AH-P-106c.

11.3. Stuffing boxes with non-adjustable packing glands designed for use of "split V type" packing are acceptable if requested by the purchaser. Glands of this design shall conform to the requirement of Sec. 11.1, allowing replacement of packing without disturbing any part of the valve or operator assembly.

TABLE 6
Minimum Operator Torque (Closing Only)

Valve Diam. in.	Torque—ft-lb										
	M-25 -25	M-25 -35	M-50 -35	M-25 -F	M-50 -F	M-100 -F	M-150 -F	M-200 -F	M-100 -60	M-150 -60	M-200 -60
3						23	28	38	13	16	21
4						51	72	96	29	32	42
6						172	248	328	100	110	141
8						424	594	782	240	257	339
10						826	1,210	1,570	472	504	670
12						1,456	2,140	2,740	810	842	1,175
14						2,340	3,330	4,280	1,290	1,350	1,880
16						3,375	4,900	6,220	1,890	2,020	2,770
18						4,940	7,220	9,220	2,730	2,890	3,900
20						6,680	9,780	12,720	3,760	3,940	5,360
24	1,456	2,427	2,765	3,080	5,940	11,360	16,600	22,200	6,380	7,930	9,350
30	3,070	4,710	5,430	6,014	11,560	22,270	32,440		12,560	13,150	
36	4,960	8,210	9,450	10,400	20,130	38,650	56,300		21,620	22,700	
42	7,930	13,000	14,940	16,600	32,200	61,600	89,900		34,800	36,700	
48	14,260	19,420	22,200	24,680	47,950	92,700	134,000		52,100	54,200	
54	16,630	27,500	31,600	35,000	67,700	129,500	188,200		73,300	76,700	
60	23,000	36,000	43,600	48,500	94,200	179,800	242,400		100,700	105,100	
66	30,600	50,600	58,000	64,900	125,600	241,000	349,800		135,200	142,000	
72	39,450	65,450	73,600	83,450	162,000	307,000	453,000		174,900	185,000	

that gland leakage cannot enter the operator case. Stuffing boxes shall have a depth not less than the diameter of the valve shaft for shafts up to 5 in. in diameter, and a depth of not less than 5 in. for shafts greater than 5 in. in diameter.

11.2. Stuffing boxes shall be made of cast iron (ASTM A126) or cast steel (ASTM A27). Gland assemblies shall be of cast bronze (ASTM B132). Unless otherwise specified by the purchaser, stuffing box packing shall be made of asbestos conforming

Sec. 12—Operators

12.1. Operators capable of seating and unseating the valves under the most adverse conditions (opening against the full design pressure and velocity as specified for each class into a dry system downstream) shall transmit a minimum torque to the valve shaft as specified in Table 5. The torque with the valve closed shall not exceed the torques specified in Table 5 by more than 175 per cent, up to 100 ft-lb; 130 per cent, from 100 to 1,000

ft-lb; 115 per cent, from 1,000 to 10,000 ft-lb; and 110 per cent, above 10,000 ft-lb. All structural parts of the operator mechanism shall be designed with a safety factor of five, based on the ultimate strength of the material and the required operator torque. The valve shaft at the connection to the operator shall be capable of transmitting the maximum operator torque without exceeding a torsional shear stress of 11,500 psi. A valve position indicator shall be furnished.

In the event that the valves will be subjected to the specified velocities or free discharge on closing cycle only, the minimum operator torques may be reduced to the values listed in Table 6.

Sec. 12.2—Gearing

12.2.1. Operators that are composed of worm gearing shall be totally enclosed in a gear case and shall have worm gears of bronze and worms of hardened steel which operate in a lubricated bath.

12.2.2. Operators of the spur and rack type of gearing shall have gears of "gear" bronze and racks of hardened stainless steel and shall be enclosed, if specified by the purchaser; or shall have gears and racks of at least 40 points carbon content and shall have hardened surfaces of at least 250 Brinell hardness. Carbon-steel gears and racks shall be totally enclosed and provided with a means of lubrication.

12.2.3. Operators of the traveling-screw type shall have threaded reach rods of steel and shall have a lubricated bronze nut. The operator shall be furnished with a protective guard. Operators shall be enclosed if specified by the purchaser.

Sec. 12.3—Manual Operators

12.3.1. Valves purchased with "manual" operators shall be furnished with

operators that require a maximum input force on a handwheel or chain-wheel of not more than 40-lb pull to develop the operator torques.

12.3.2. Manual operators shall be provided with a suitable mounting for future electric operators.

12.3.3. Manual operators shall be furnished with a device to hold the valve in a fixed position for an extended period of time.

Sec. 12.4—Electric Operators

12.4.1. In electric operators, motors shall be capable of producing the torque specified in Tables 5 and 6 at the required time cycle of valve operation.

12.4.2. Electric motor drives shall be equipped with one pair of limit switches and one pair of torque switches.

12.4.3. Any gearing in direct association with the electric motor drive shall be totally enclosed and shall operate in a lubricated bath.

Sec. 12.5—Hydraulic Cylinders

Unless otherwise specified by the purchaser, hydraulic cylinders shall comply with the following specifications:

12.5.1. Cylinder bodies shall be of a low-zinc-content bronze with the inside diameter honed to at least a 15-RMS (root-mean-square) finish.

12.5.2. Cylinder pistons and head and cap ends shall be of a ferrous material with complete corrosion protection on all surfaces. This corrosion protection shall withstand a minimum of 300 hr in the Army-Navy salt spray test. (Refer to Federal Specifications QQ-M-151a).

12.5.3. Cylinder piston rods shall be of stainless steel having a 5-10-RMS finish, with a surface of hard chrome

plating of approximately 0.0005-in. thickness.

12.5.4. Piston rod bushings shall be of bronze and shall be pilot fitted into the cylinder head.

12.5.5. Cylinders shall be equipped with a dirt wiper to clean the piston rod before it enters the cylinder.

12.5.6. Cylinders shall be equipped with rod seals of a nonadjustable, wear-compensating type.

12.5.7. Rod seals and piston cups shall be of "Hycar" * rubber or equal.

12.5.8. Cylinders shall require not more than the pressure listed in Table 7 to be cycled a complete stroke in either direction before they are connected to the butterfly valve.

TABLE 7
Pressure to Move Cylinder

Cylinder Bore in.	Pressure psi
2 or less	5
2+ through 5	4
More than 5	3

Sec. 12.6—Pneumatic Cylinders

Unless otherwise specified by the purchaser, pneumatic cylinders shall comply with the following specifications:

12.6.1. Cylinder bodies shall be of hard-drawn brass with the inside diameter honed to at least a 15-RMS finish; or of steel, bored, honed, chromium plated, and re honed to at least a 15-RMS finish.

12.6.2. Cylinder head and cap ends shall be of steel or of cadmium-plated cast iron.

12.6.3. Cylinder pistons shall be of chromium-plated steel, hard-coated aluminum aluminite or cadmium-plated cast iron.

* A trade name of B. F. Goodrich Chemical Co., Cleveland, Ohio.

12.6.4. Cylinder piston rods shall be of stainless steel having a 5-10-RMS finish, with a surface of hard chrome plating of approximately 0.0005-in. thickness.

12.6.5. Piston rod bushings shall be of bronze and shall be pilot fitted into the cylinder head.

12.6.6. Cylinders shall be equipped with a dirt wiper to clean the piston rod before it enters the cylinder.

12.6.7. Cylinders shall be equipped with rod seals of a nonadjustable, wear-compensating type.

12.6.8. Rod seals, rod wiper, and piston cups shall be of neoprene, "Hycar," * or synthetic leather suitable for air service.

12.6.9. Cylinders shall be equipped with adjustable cushions at each end of the stroke.

12.6.10. The structure of the cylinder shall have a safety factor of at least five based on the working pressure. Where cast iron is used, this safety factor shall be at least ten.

12.6.11. Cylinders shall require not more than the pressure listed in Table 7 to be cycled a complete stroke in either direction before they are connected to the butterfly valve.

Sec. 13—Testing

13.1. *Performance tests.* After completion, each valve shall be shop operated three times from the fully closed to the fully opened position, and vice versa, under a no-flow condition, to demonstrate that the assembly is workable.

13.2. *Leakage tests.* Each valve shall be shop tested for leaks in the closed position under full operating pressure differential for a period of at least 5 min. With the disc in the closed position, leakage rates shall not exceed the values listed in Table 8

with full pressure differential across the closed disc.

13.3. *Hydrostatic tests.* With the valve disc in the slightly open position, internal hydrostatic pressure equivalent to two times the specified shutoff pressure shall be applied to the inside of the valve body for a period of not less than 10 min. Under the specified hydrostatic test, there shall be no leak-

designed, and manufacturing tolerances set, to provide interchangeability in the products of any one manufacturer between units of the same size and type. When assembled, valves manufactured in accordance with these specifications shall be well fitted and smooth running, and the bodies and packing shall be watertight. All equipment shall be guaranteed against defects in work-

TABLE 8
Maximum Leakage

Valve Diameter in.	Leakage—gpm				
	Class of Valve				
	25 psi	50 psi	100 psi	150 psi	200 psi
3			0.1	0.2	0.2
4			0.2	0.3	0.3
6			0.3	0.4	0.4
8			0.4	0.5	0.6
10			0.425	0.6	0.7
12			0.45	0.9	1.0
14			0.5	1.0	1.1
16			0.6	1.1	1.4
18			0.75	1.2	1.7
20			0.9	1.3	2.0
24	0.3	0.4	1	1.5	2.5
30	0.4	0.6	1.2	2	
36	0.6	0.8	1.4	2.5	
42	0.7	1	1.5	2.75	
48	0.8	1.25	1.75	3	
54	1.0	1.5	2.0	3.5	
60	1.2	1.75	2.25	4	
66	1.4	2	2.5	4.5	
72	1.5	2.3	3	5	

age through the metal, the flanged joints, or the valve packing gland, nor shall any part be permanently deformed.

Sec. 14—Workmanship

The workmanship in the fabrication and assembly of valves covered by these specifications shall be first class in every respect. Valve parts shall be

manship or materials for one year after shipment has been made.

Sec. 15—Marking

Markings shall be cast on the body or shall be on cast plates with raised letters, welded to the valve body. The markings shall show the valve size, manufacturer, class, and year of manufacture. The minimum size of letters

shall be $\frac{1}{4}$ in. for valves 3-12 in. in diameter, and $\frac{1}{2}$ in. for valves larger than 12 in. in diameter.

Sec. 16—Painting

Unless otherwise specified by the purchaser, an asphalt varnish made to comply with Federal Specifications TT-V-51a, or US Army and Navy Specifications JAN-P-450, shall be applied to the ferrous part of the valves, except to finished or bearing surfaces. Surfaces shall be clean, dry, and free from grease before painting. Two coats each shall be applied to the inside and outside ferrous metal.

Sec. 17—Inspection and Rejection

17.1. All work done under these specifications shall be subject to inspection and approval by the pur-

chaser's duly authorized engineer or inspector, who shall at all times have access to all places where materials are being produced or fabricated or where tests are being conducted, and who shall be accorded full facilities for inspection and observation of tests. Any butterfly valve or part which the inspector may condemn as not conforming to the requirements of these specifications shall be made satisfactory or shall be rejected and replaced.

17.2. If the purchaser has no inspector at the plant, the manufacturer shall, if requested at the time the order is placed, certify that the required tests on the various materials and on the completed valves will be made, and that no component or valve shall be furnished which has not been tested and found to conform to the requirements of these specifications.

Revision of Rubber-seated Butterfly Valve Specifications

On Nov. 7, 1955, the AWWA Board of Directors approved extensive revisions in the Tentative Standard Specifications for Rubber-seated Butterfly Valves—AWWA C504-54T, originally published in the September 1954 JOURNAL. The designation of the specifications has been changed to C504-55T. In the following summary of the changes, the revisions are shown in *italics*:

Sec. 1—Scope

1.1, lines 5-6: "*pressures and line velocities as indicated in Table 1, together . . .*" Lines 11-13: "*in a throttled position in water lines.*"

1.2, line 3: "[*pres*]sure indicated in Table. . ."

1.4, lines 1-2: "*Torque requirements for valve operation vary considerably with increases in design pressure and fluid velocity. . .*" Line 10: "*those shown in Table 1, for valves which will be subjected to the maximum design shutoff pressure designated for each class.*"

Sec. 2—Information to Be Supplied by Purchaser

2.6. Add at end: "*If electric operation, power characteristics for motor; if cylinder operation, medium available (air, water, or oil) and minimum and maximum pressure available for cylinder operation.*"

2.7. Delete existing paragraph and substitute: "*Time of operation (unless otherwise specified, power-operated valves shall operate from full-open to full-closed position, or vice versa, in approximately 60 sec).*"

Sec. 3—Data to Be Furnished by Manufacturer

This section has been broken up into two new sections: Sec. 3—Data to Be Furnished by Bidder, consisting of the old paragraphs 3.1 and 3.2, somewhat revised; and Sec. 4—Data to Be Furnished by Manufacturer, consisting of the old paragraphs 3.3 and 3.4, slightly reworded.

These changes have made it necessary to renumber succeeding sections. In the revisions below, the old numbers are shown first, with the new ones following in brackets:

Sec. 5 [6]—Valve Bodies and Flanges

5.1 [6.1], line 8: "*fittings. As an. . .*"
Line 13: "*25-psi cast-iron fittings. . .*"

5.3 [6.3], line 4: "*(ASTM A126, Class B). . .*"

Sec. 6 [7]—Valve Shafts

6.3 [7.3], lines 8-9: "*of the torsional strength of the minimum required shaft diameters. . .*"

6.4 [7.4], line 9: "*fillets to minimize the. . .*" Lines 15-16: "*the torsional strength of the minimum required shaft diameter.*"

Sec. 7 [8]—Valve Discs

7.1 [8.1], line 7: "*of the tensile strength of. . .*"

7.2 [8.2], lines 5-8: "*[con]forming to ASTM A7; of cast bronze (conforming to ASTM B61 or ASTM B143); or of alloy cast iron (Military Specifications MIL-G-858a, Class I). Valve discs of cast iron (ASTM A48, Class 40), cast steel, or fabricated steel shall have seating edges of 18-8 stainless steel, Monel, or bronze covering the full width of the disc seating edge. Sprayed-metal seats are not acceptable.*"

7.3. Delete paragraph.

Sec. 8 [9]—Valve Seats

8.3 [9.3]. In Table 8, first referred to in this paragraph, the title has been changed to: "*Minimum Operator Torque for Most Adverse Conditions,*" and the following footnote has been added: "*For the less adverse condition of opening against the full design pressure and velocity as specified for each class into a flooded system downstream, operator torques marked by an asterisk (*) can be appreciably reduced. When operating*"

conditions (pressures or velocities) fall between the classes specified, an adjustment may be made in the torque values."

The torque values marked with an asterisk are those for Class 25-8 applying to valves of 36-in. diameter and larger; Class 25-16, 16-in. and larger; Class 50-8, 48-in. and larger; Class 50-16, 16-in. and larger; Class 125-8, none; and Class 125-16, 30-in. and larger.

8.4 [9.4]. In Table 6, referred to in this paragraph, the following changes in minimum seat thickness values (inches) have been made: for 6-in. valves (all classes), $\frac{1}{16}$; 8-10-in. valves, $\frac{3}{8}$; 12-14-in. valves, $\frac{1}{8}$; 16-20-in. valves, $\frac{1}{2}$. For other sizes, the old values remained unchanged.

8.5 [9.5]. "Valve seats shall be of natural rubber. The rubber seat may be reinforced if desired by the manufacturer. Valve seats shall be either: (a) cemented or vulcanized and clamped into the valve body; or (b) cemented or vulcanized into the valve body. If of Type (b), the rubber seat shall extend out over the face of each body flange."

Add the following paragraph:

[9.6]. "In valves containing bronze disc seating surfaces, the rubber shall contain anti-copper poisoning ingredients."

Sec. 9 [10]—Valve Bearings

9.1 [10.1], line 8: "pressure not exceeding 2,500. . ."

9.4 [10.4], line 4: "not have a harmful effect on water or rubber and. . ." Line 12: "lubricated material or of the. . ."

Sec. 10 [11]—Stuffing Boxes

10.1 [11.1], line 12: "shaft for shafts up to 5 in. in diameter, and a depth of not less than 5 in. for shafts greater than 5 in. in diameter."

Add a new paragraph at the end of this section:

[11.3]. "Stuffing boxes with nonadjustable packing glands designed for use of 'split V type' packing are acceptable if requested by the purchaser. Glands of this design shall conform to the requirement of Sec. 11.1, allowing replacement of

packing without disturbing any part of the valve or operator assembly."

Sec. 11 [12]—Operators

11.1 [12.1]. "Operators capable of seating and unseating the valves under the most adverse conditions (opening against the full design pressure and velocity as specified for each class into a dry system downstream) shall transmit a minimum torque to the valve shaft as specified in Table 8. The torque with the valve closed shall not exceed the torques specified in Table 8 by more than 175 per cent, up to 100 ft-lb; 130 per cent, from 100 to 1,000 ft-lb; 115 per cent, from 1,000 to 10,000 ft-lb; and 110 per cent, above 10,000 ft-lb. All structural parts of the operator mechanism shall be designed with a safety factor of five, based on the ultimate strength of the material and the required operator torque. The valve shaft at the connection to the operator shall be capable of transmitting the maximum operator torque without exceeding a torsional shear stress of 11,500 psi. A valve position indicator shall be furnished."

11.2.2 [12.2.2], line 2: "rack type of gearing shall have gears of 'gear' bronze and racks of hardened stainless steel and shall be enclosed, if specified by the purchaser; or shall have gears. . ." Line 6: "Carbon-steel gears and racks. . ."

11.2.3. [12.2.3], lines 3-4: "rods of steel and shall have a bronze nut with internal threads. Operators shall be enclosed if specified by the purchaser."

11.4.1 [12.4.1]. Delete lines 5-9.

11.5.1 [12.5.1]. "Cylinder bodies shall be of a low-zinc-content bronze, with the inside diameter honed to at least a 15-RMS (root-mean-square) finish."

11.5.2 [12.5.2]. "Cylinder pistons and head and cap ends shall be of a ferrous material with complete corrosion protection on all surfaces. This corrosion protection shall withstand a minimum of 300 hr in the Army-Navy salt spray test. (Refer to Federal Specifications QQ-M-151a)."

11.5.3, 11.5.4. Delete these paragraphs. Renumber succeeding paragraphs 12.5.3

through 12.5.8. Add a new section, 12.6, on pneumatic cylinders. (As this section is similar in wording to Sec. 12.6 of AWWA Specifications C505, printed on p. 213 in this issue, it is omitted here.)

Sec. 12 [13]—Testing

12.1 [13.1], line 3: "[oper]ated three times. . ."

12.2 [13.2], lines 3-4: "closed position. This test shall. . ."

12.3 [13.3], lines 4-10: [equiva]lent to two times the specified shutoff pressure shall be applied to the inside of the valve body for a period of 10 min. Under the. . ."

Sec. 13 [14]—Workmanship

Lines 11-12: "specifications shall be well fitted and smooth running, and the body and packing gland shall be watertight. . ."

Sec. 14 [15]—Marking

Lines 2-5: "or shall be on cast plates with raised letters, welded to the valve body. The marking shall show the valve size, manufacturer, class, and year of manufacture. The minimum size of letters shall be $\frac{1}{4}$ in. for valves 3-12 in. in diameter, and $\frac{1}{2}$ in. for valves larger than 12 in. in diameter."

Revision of Steel Pipe Coating Standards

On Jul. 14, 1955, the Board approved the following revisions to Standard Specifications for Coal-Tar Enamel Protective Coatings for Steel Water Pipe (AWWA C203—Sizes 30 in. and Over; AWWA C204—Sizes up to 30 in.):

The paragraph dealing with the weight of asbestos coal-tar saturated felt (Appendix Sec. A5-2.1.2 of C203, and Sec. 6-2.5.2 of C204) has been revised to read:

Weight per 100 Sq.Ft.: Exclusive of all comminuted surfacing or sand which has been added to prevent sticking in the rolls, the weight shall be not less than 12 lb. nor more than 15 lb. per 100 sq.ft.

Test Method: A.S.T.M. Designation: D146-47, Sections 1-9.

The paragraph dealing with saturation of the felt (Appendix Sec. A5-2.1.5 of C203, and Sec. 6-2.5.5 of C204) has been revised to read:

Saturation: Average after test samples from the inside of the roll have been aged in free air for 72 hr. The saturation by extraction shall be not less than 22 per cent nor more than 32 per cent of the weight of the extracted felt.

Test Method: A.S.T.M. Designation: D146-47, Sec. 16, omitting correction for entrained carbonaceous materials, calculated as follows:

$$\frac{\text{wt. of extracted saturant} \times 100}{\text{wt. of extracted felt (as defined)}} = \% \text{ saturation}$$

The specifications have been redesignated C203-55 and C204-55.

The following changes have been made in the date of ASTM designations referred to in these specifications: ASTM D88-38 changed to D88-53; ASTM D146-27, to D146-47; ASTM D154-28, to D154-53; and ASTM D287-39 to D287-53T. Also, in AWWA C203, Appendix Sec. A5-2.2—Portland Cement, ASTM C9-37 has been changed to ASTM C150-53.



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activated carbon has to be a flexible operation. If taste and odors in raw water increase due to seasonal conditions the dosage must be stepped up. Likewise when the amounts of objectionable odor fall off to a normal level, the dosage requirements of Aqua Nuchar activated carbon decrease. Constant checking by Threshold Odor Tests assures water plant operators of

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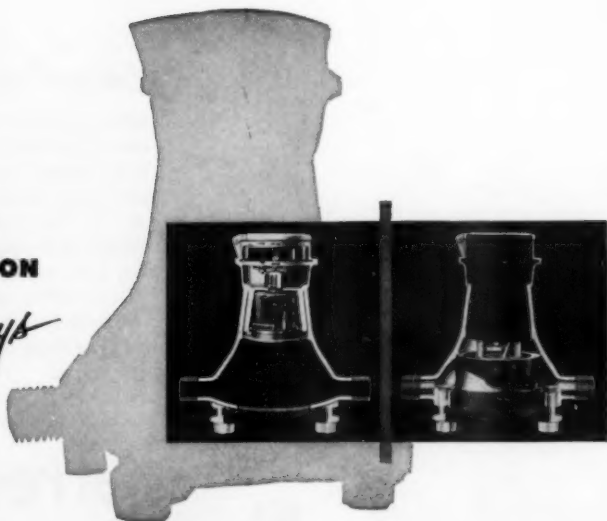
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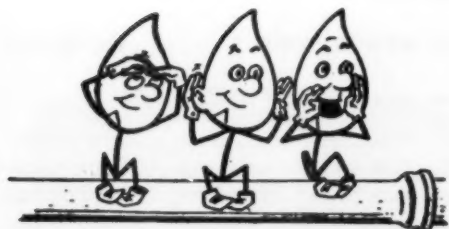
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Percolation and Runoff

AWWA's big wheels were really turning last Jan. 15-17, when 38 of the Association's 40 directors answered the roll call for the Board's 75th birthday meeting and then spent 18 of the next 48 hr in solid session, churning through an agenda worthy of at least a week's work. Perhaps it was the lack of a Jack among them that obviated the classic effect of all that work and no play. At any rate, they didn't appear to be going around in circles at any time except during those occasional recesses granted them for eating, sleeping, and the other necessities. No doubt that's why, in AWWA, unlike other organizations, one can't always tell a big wheel by his rubber tire.

Lest these affairs begin to sound a little too grim to be tolerated, however, we hasten to point out that even when they are together, your representatives sometimes manage to be a little less than serious. If not before, at Sunday dinner, with the directors' directors on hand to dry out the conversation a bit, things began to brighten, particularly when Wagering William, better known as Betting Bill, Orchard took charge of relieving each diner, first, of a dollar to accompany his estimate of the St. Louis Conference registration and, then, a quarter, to contribute to the well being of Cliff Casad (\$12) and Mrs. George Norcom (\$6.50) as the best and next best coin flippers in the crowd. Then, only

after the ladies had staggered away with bulging bags of Temple oranges and tremendous grapefruit, provided for the occasion through the generosity of the Florida Section, did things get back to long-face again. Monday's luncheon, relaxed a bit by the drinks set up by the retiring directors, provided an opportunity for a representative of the Keep Officers Gump-tious and Reflective Association (Keep Off GRass, that is), to present Past-President-Nominate Frank Amsbary with a light-bulbish "radiograph" upon which to meditate during the lazy days of his postpresidency, and President-Nominate Paul Weir, with a king-size "magic" 8-ball not only to signify his future position, but to give him the answers asked of any past-vice-president.

This, of course, was only the official divertissement. The week's financial reports of various Broadway restaurants, shows, and night spots would seem to indicate that money flowed like water through some of the hours reserved for sleep. Little wonder, then, that Tip Allen was moved to conclude that "man stands with one foot in the grave and the other on a banana peel." Things looked brighter, no doubt, on Tuesday noon, when 350 New York Section members and guests gathered to give the Board a sendoff luncheon. And by next May in St. Louis, all the wheels should be around again—finally untired.

(Continued on page 36 P&R)

(Continued from page 35 P&R)

Dog-tired meter readers will soon have a haven if our deductions from a recent communication from Pretoria, South Africa, are not too far off the beam. At any rate, we recently had a request from P. R. Richardson, Hon. Secretary of the Pretoriase Hondeskool (Pretoria Dog School, that is) for a copy of AWWA's *Rx for Meter Readers*, the safety manual for approaching strange dogs. And almost the only conclusion that we can draw is that Mr. Richardson proposes to teach his scholars the proper reaction to the proper action by meter readers. If this is true, for 5¢ (adv.) plus the price of a ticket to Pretoria any meter reader can escape being hounded all his days.

Talk about literacy!

First things first in the Philippines these days. Thus, when First Lady Mrs. Ramon Magsaysay paid a visit to Los Angeles the other month, the money raised at a banquet held in her honor by the Philippine community there was dedicated to the drilling of wells in the Islands. In her thanks for the gift, Mrs. Magsaysay pointed out that her husband believed that a safe water supply was the essential first step in raising the country's living standards. Hear! Hear! Magsaysay!

Herbert E. Hudson has been named head of Hazen & Sawyer's new Detroit office. His first project will be a 200-mgd addition to that city's Springwells Filtration Plant.

Fred Merryfield, professor of sanitary engineering at Oregon State College, Corvallis, has been appointed to the newly created State Water Resources Board. A former secretary-

treasurer of the Pacific Northwest Section and the new vice-president-nominee of AWWA, Prof. Merryfield has done much research on stream pollution and hydrology.

Atomic-energy problems were studied and discussed by the more than 2,700 persons attending the engineers Joint Council Nuclear Engineering and Science Congress held at the Public Auditorium in Cleveland, Ohio, Dec. 12-16, in conjunction with the International Atomic Exposition sponsored by the American Institute of Chemical Engineers. The 240 papers presented at 50 technical sessions dealt with the significant aspects of the nuclear industry in a peaceful world. The papers were sponsored by 28 national societies and associations in engineering or related fields. The fifteen AWWA-sponsored papers covered such subjects as detection and monitoring of nuclear debris in water, removal of fission products from aqueous solutions, disposal of radioactive wastes, and pollution by radioactive fallout.

The exhibits were numerous and awe inspiring, particularly to the uninformed. With the help and instruction of exhibit attendants, however, the neophyte was soon able to recognize a nuclear reactor and even to understand something of its operation and control. Much of the mystery of nuclear fission was thereby dispelled with new and practical information. The exhibit was undoubtedly as important to the success of the congress as were the technical sessions.

The congress and exposition indicated quite plainly that the atomic age is here right now, not around the corner. The effects on all of us become more pronounced each day.

(Continued on page 38 P&R)



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WORLD'S LARGEST
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5542

Offices in principal cities in North America

(Continued from page 36 P&R)

New Jersey, Texas, and Blondie were all in the same boat a couple of months ago after the hottest water debates in their histories—all more or less victorious and all drier than ever. New Jersey, having argued its Chimney Rock water supply proposition to election death, was busy setting up ten more plans in the other alley, with the prospect of continued activity but no result. In Texas, it was the legislature itself that wrangled self-righteously over methods of financing water conservation until it came to adjournment without enacting a statewide program. Blondie, meanwhile, was claiming no more than a tie in her argument with the water company over a high bill—the company getting no money and she and Dagwood, no water. Not having had the opportunity to review Blondie's reasons and reasoning, we cannot comment, but there certainly can be no denying that the arguments in both New Jersey and Texas were good and strong—on both sides. Now it remains for them all to get thirsty enough to give a little to get a little. Dagwood will tell Blondie, but who's going to do the honors for the others?

Charles J. Alfke, executive vice-president of Hackensack Water Co., Weehawken, N.J., has been elected president of the New Jersey Utilities Assn.

WANTED

January 1955 Journals

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steel toe plate slips under the tank, and the truck is then tipped back on the rear swivel casters, which are equipped with lock brakes.

Samuel P. Felix has been appointed vice-president of De Laval Turbine Pacific Co. He continues as general manager. This subsidiary of De Laval Steam Turbine Co. recently opened a new sales and service center at Millbrae, Calif., near San Francisco.

Mueller Co., Decatur, Ill., has made a number of sales staff appointments and promotions: Russell L. Jolly, Chicago, is the new Midwest Section sales manager, Paul B. Watts replacing him as sales representative in the Chicago area. Dan Gannon moves to Los Angeles as Western Section sales manager and is succeeded as Southwest Section sales manager at Dallas, Tex., by Richard D. Kitchen.

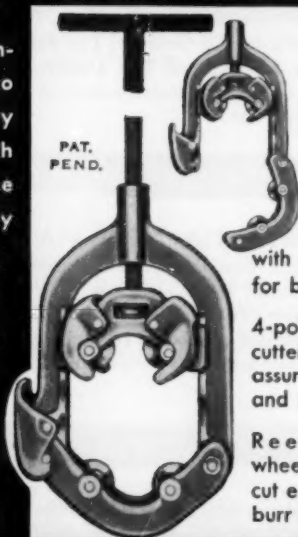
(Continued on page 42 P&R)

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The production facilities of the combined Companies have been consolidated and at the same time are being greatly expanded. Only the newest, most modern equipment has been retained. Hundreds of thousands of dollars worth of new equipment is expanding the capacity and giving even greater assurance of our ability to serve. This means insurance for you, more local stocks to draw on, and shorter deliveries on heavy equipment. This all means lower inventories for you.

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- Rensselaer

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THE BEST IN EXPERIENCE

The combined Companies have had experienced engineers in the field in every State of the Union for a total of 165 years of service. These men have helped you, you have helped them, and in turn they have helped many others. The results of this close contact over a long period have been reported back and catalogued to become an up-to-date "Encyclopedia" for the Water Works field.

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Sales Engineering in the field backed by the extensive fund of knowledge in the home office is the art of locating the right product in the right place at the right time, with the lowest possible cost and installation time. In most cases an error in the original selection can cost far more in digging, flooding or stoppages, than the original equipment. In other cases, the sales engineer may make important savings in the installation cost.

AND THE TRADITIONS GO ON

The names, Ludlow and Rensselaer mean the same today that they have during your lifetime. The desire to serve the Water Works Field in person—in research and design and in prompt delivery of original equipment and spare parts for all products has not changed. On the other hand, our ability to serve has at least doubled.

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11

TROY, NEW YORK

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CHECK VALVES • TAPPING SLEEVES • AIR RELEASE VALVES

(Continued from page 38 P&R)

In recognition of their work on developing the membrane filter technique of bacteriological analysis, Paul W. Kabler, Harold F. Clark, Edwin E. Geldreich, and Harold L. Jeter—all with the USPHS Robert A. Taft Sanitary Engineering Center, Cincinnati—have been selected for the 1955 Kimble Methodology Research Award. Readers of the JOURNAL will recall their articles on the subject during the past several years.

Another Macedonia came close to making a big conquest recently, only to be foiled by an inadequate water supply. This was Macedonia, Ohio, and its conquest was to be the Chrysler Corporation's new \$85,000,000 stamping plant—one of the biggest of its kind ever built. As a matter of fact,

Chrysler had already announced selection of the 1,200-population town as the site when some test borings and a closer look at the water supply changed its mind. Some idea of what Macedonia forfeited is suggested by this measure of a new industry's impact on a community, from a recent issue of *Manufacturers Record*:

A new industry coming into a community and employing 150 men would mean an average plant investment of \$200,000 and provide an annual payroll of \$500,000. It would also serve as the major support of 33 retail establishments, maintain a 33-room schoolhouse with 18 teachers, and be the means of support of approximately 1,000 people. It would also mean sales and services for 449 automobiles, \$199,999 annually for the railroads, and opportunities for 24 professional men.

(Continued on page 44 P&R)

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Fittings—2 through
24 inch.

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(Continued from page 42 P&R)

A taxable valuation of \$2,500,000, yearly markets for \$350,000 in agricultural products, and annual expenditure in trade of \$1,500,000.

If these figures are applicable to the Chrysler case, all Macedonians have to do to determine what their lack of water supply cost them is to multiply all of them by 425. Then again, perhaps they'd better not. After all, at an average investment of \$200 per capita, just building up the water system to take care of the resulting 425,000 "supported" population would cost \$70,833.33 apiece for the present residents. What price water—or, for that matter, statistics?

The ten billion fresh gals that the Charleston, S.C., Development Board is advertising these days, in a bid to bring industry to the city, might sound

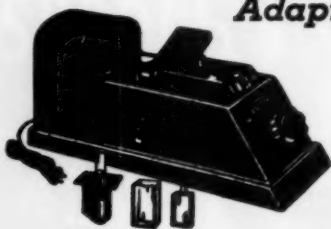
positively immoral were it not for the fact that the "gals" are guaranteed not only fresh, but soft. That antithesis, of course, is enough in itself to assure us that it is water, not women, whereof they speak. But even as "10 bgd" these days, the number is hardly less appealing. After all, there are already more than enough of the other type to go around.

Four bells in a bath, meanwhile, might be providing just as much excitement in Lawrence, Mass., were it not for the fact that these bells are bells, not belles, that peel, not peel, before a bath, and ring, not wring, out after one. Besides, there is excitement enough in the price of \$2,165 that the freshening up will cost the city by the time the—well—chimes are reinstalled in the city's "water tower."

(Continued on page 46 P&R)

KLETT SUMMERSON ELECTRIC PHOTOMETER

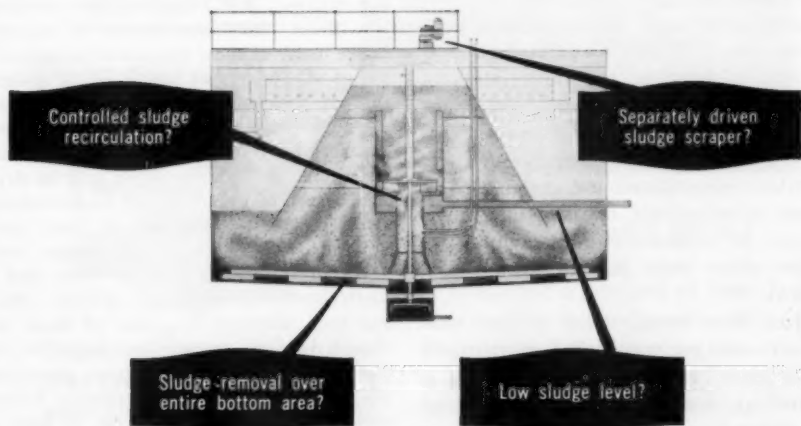
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(Continued from page 44 P&R)

The broadening effect of travel is suddenly spreading out to include water as well as to bridge it. And with more people traveling every year, and traveling further, the appreciation of safe drinking water supplies ought soon to become widespread. Word from overseas, as well as warning to overseers, these days almost always contains some comment on drinking water, which, at least in the hinterlands of even some of the most advanced countries, has a tendency to be untrustworthy. The answer usually comes in bottles—mineralized and carbonated in some substitutions, distilled and spirituous in others—with the tap tabu more often than not all around the world.

Just how broad some of our customers can get was well demonstrated in a letter written to his family by a traveling Hoosier layman from a land of *caveat bibor*:

In some ways Teheran reminds me of Salt Lake City. The Elburz Mountains impinge upon the northern suburbs like the Wasatch Mountains frame the eastern outlook from the capital of Utah. Snow-covered Mt. Demavend, altitude 18,834 ft, highest peak in the Elburz (and I believe in all Persia), is visible off to the northeast only about 50 miles away. As the crow flies, it is about halfway to the Caspian Sea, but, over the circuitous route shown on my map, it is probably 3,000 miles from Teheran. Another similarity with Salt Lake City is the fact that there are fairly deep gutters with flowing water alongside many of the main streets. While the stream flow is not exactly limpid, the very fact of flowing water gives some subconscious feeling of cleanliness.

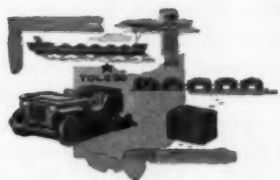
As in most of the Middle East, residences, apartment houses, even many of the places of business are enclosed in compounds. These are probably, to a large

extent, the modern and urban expression of the time-honored architectural unit wherein were housed several generations of persons, including members of the extended family, such as brothers and nephews. Such a housing tradition extends from Africa through the Middle East to China. The logical basis for such encompassed and circumscribed dwelling is without doubt some degree of security. Since many of these compound gardens or patios are jewels to behold, it is evident that if the compound dwelling had no aesthetic basis, many of the compound dwellers have made the best of a difficult situation. A Teheran street may be drab and barren of greenery, but an occasional royal poinciana, oleander, or lowly convolvulus peering over a compound wall gives promise of a riot of colors and a meticulously tinsured lawn within. Having been admitted to a few of these enclosed dwelling spaces, you begin to feel that your friends or business associates are dwelling in a San Fernando Valley opulence, for everyone seems to have a swimming pool. Then it seems that the pools are perhaps too shallow, too small, and, above all, too cold for bathing. Observation indicates that they are not for lilies or goldfish. A little sleuthing and discreet inquiry reveals that they are settling basins for the dwelling's water supply. Completely disillusioned, you discover that the city's water supply is the slipping, sliding, glooming, glancing, gurgling, gutter stream where the ubiquitous donkey pauses to slake his thirst, where the office boy washes the overworked office tea set, and the weary porter squats on the curb to lave his burning feet. Amidst all the signs of progress and evident modern hygiene, it comes as a shock to realize that the water in which you took your morning's shower arrived at the hotel through the gutter.

From the settling basin in the yard, water is drawn from the top and into a settling cistern under the house. Thence, after a period of repose and, presumably, clarification by gravity and anaerobic

(Continued on page 48 P&R)

Toledo Prefers Concrete Pressure Pipe



Toledo engineers prefer concrete pressure pipe for the city's water supply mains. In 1948 an 8,600-foot installation, known as the Bancroft Street Crosstown Main, was completed. Since then 24", 36", 48" and 72" concrete pressure pipe has been used in major additions to the city's water supply system. Just recently contracts have been signed by Lucas County authorities and work is in progress on additional projects in the



Toledo area, involving 16" and 24" pipe.

There are a number of reasons for Toledo's increasing use of concrete pressure pipe. Sustained high-carrying capacity and long life are two of the most important. Another is low maintenance cost. The original cost is also low and installation is accomplished quickly and easily.

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(Continued from page 46 P&R)

bacterial activity, it is pumped to a tank on the roof, whence it flows by gravity to the various sanitary and ablutionary fixtures. No, you don't drink this water. You don't even wash your teeth in it. After you discover the truth, you close your eyes and hold your breath while you take a shower; but you still have to bathe. An investigation of the distribution system reveals that one day the water is available in the gutters along one set of streets, and the next day along some other network. To replenish your water supply you have to look alert and be on schedule. I saw one fellow building a rock dam across the gutter in order to divert into his subterranean system the major portion of the flow. To heck with the fellows farther down the stream!

The distribution of potable water furnishes an occupation for a great number of persons. Water for cooking and drinking purposes is transported throughout the city in large casks holding probably 500 gallons each, mounted on one-horse, two-wheeled carts. From these it is hawked from door to door, the householder bringing his own container to be filled. As in all oriental and many European hotels, drinking water is supplied to your room in a carafe or thermos bottle. It is from this supply that you obtain the water to wash your teeth. As a result of the almost universal contamination of the water, there is a great vogue among the foreigners and the elite for the consumption of bottled water. The presence on your dining table of a bottle of Aba Ali is as surely a badge of distinction (or at least of discretion) as a bottle of Calvert in America. Aba means water. Ali is the name of a neighboring mountain, the scene of a famous spring. This carbonated mineral water is bottled in small bottles, holding no more than a Coca Cola bottle, and sold for 10 rials, about 13 cents US, per bottle. For those with a lustier taste, there is available in similar bottles Duk Aba Ali, a mixture of this carbonated water and sour milk. It looks and tastes like Robert's Dairy had

saved and bottled the water with which they had washed their milk cans. I like yogurt, but Duk Aba Ali is too much for me. . . .

How tap happy our aba-broadened friend will be after he gets back home is difficult to predict, but the \$2 per gallon cost of Aba Ali and the even worse memories of Duk Aba Ali can't help but help the cause.

Travelers, too, US Air Force Col. and Mrs. John D. Collins Jr. of Texas, stationed in Naples, Italy, recently demonstrated perhaps an even broader appreciation of the water supply back home when the time came to christen their new son. For so important a task, nothing but "pure" Waco water would do, so a supply was flown in for the occasion. If less the safety than the source of the supply was there involved, at least the Collins indicated an appreciation that water is more than just H₂O. The young James Edward, of course, sounded somewhat less than favorably impressed, but that was probably caused by the non-Texas wetting at the other end.

Owen Rice, vice-president in charge of chemical sales for Hagan Corp., has been elected a director of the company and its subsidiaries, Calgon, Hall Labs., and Buromin Co. Mr. Rice fills a board vacancy created when E. M. Chaney retired as company treasurer and director.

John B. Donohoe has been named New England District sales representative for A. P. Smith Mfg. Co., East Orange, N.J. Mr. Donohoe, who succeeds Frank F. Wells, will have his headquarters in Springfield, Mass.

(Continued on page 88 P&R)

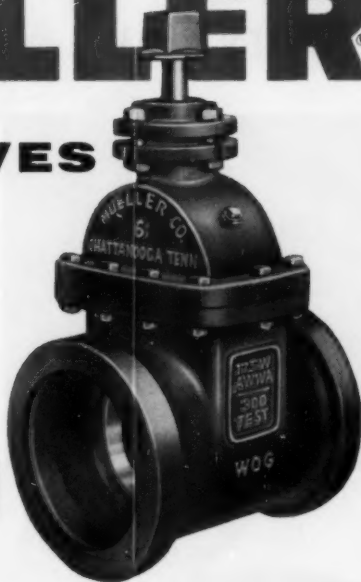
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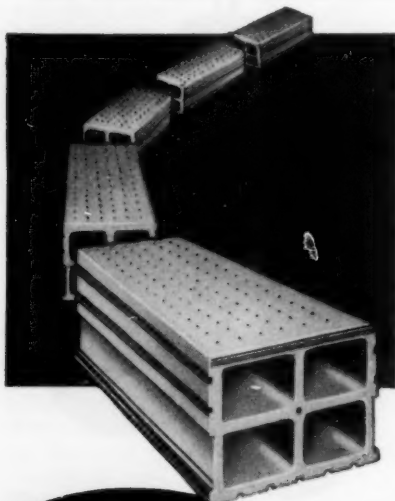
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Metallurgy

To the Editor:

I have no explanation as to the action of the pipe locator described in the July 1952 JOURNAL (p. 10 P&R), but I would like to support Mr. Yaxley's claim (October 1955 JOURNAL, p. 54 P&R) that the darn thing works.

The only thing that I can add to the confusion is that it is not even necessary to use an elaborately engineered mechanism. I have entertained groups on several occasions by simply bending wire coat hangers to the shape originally recommended and then going to work. These coat hanger pipe-locating rods will locate radiators, steel beams, water pipes, gas pipes, or anything else made of steel or iron of any size.

It's a lot of fun to watch one or two members of a party each manipulating two indicators, one in each hand. If they go over a steel member or pipe, these locators will sometimes point toward each other and sometimes in opposite directions.

I have not, however, been able to locate asbestos pipes. Apparently I am not allergic to asbestos.

A. E. GRIFFIN

Belleville, N. J.; Nov. 30, 1955

If not explanation, empiricist Griffin gives us all the clue we need to label his magic "metallurgy," a related, if not identical, manifestation of the same type of susceptibility as the "pipeallergy" that permits rod-handler Yaxley to ignore material and concentrate on fabrication. And "whatallergy" have you?

(Continued on page 52 P&R)



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(Continued from page 50 P&R)

Are Eucliding?

To the Editor:

In their article on treatment plant design (August 1955 JOURNAL), authors Howson and Aultman state (p. 732): "Because the length of the overflow weir is of major importance in the conventional sedimentation basin, a circular or square basin is the most advantageous shape. They have the longest perimeter per unit of volume."

Can it be that the concepts of relativity have disproved the conclusions of Euclidian geometry and that the cylinder does not have the shortest perimeter per unit volume? We were taught (circa 1902 AD) that the perimeter of a cylinder, r being the radius, was $2\pi r$ and that the volume, h being the height, was $\pi r^2 h$. The ratio of perimeter to volume would be $2:hr$. For a square-based prism of $2\pi r$ perimeter, this ratio comes out $2.5+:hr$. For an equilateral triangle-based prism of perimeter $2\pi r$, the ratio comes out $3.3+:hr$.

ARTHUR M. BUSWELL

Gainesville, Fla.
Oct. 5, 1955

To the Editor:

We doubt whether the conclusions of Euclidian geometry which were absorbed by Dr. Buswell "circa 1902 AD" are

being seriously challenged in our article. Can it be that because of his devotion to Euclid and his going round in circles with his $2\pi r$, the eminent doctor has overlooked the practical engineering fact that, with center-feed and radial-flow circular or square sedimentation basins, all four walls are provided with overflow weirs, whereas with rectangular basins the flow is normally from one shorter end across the length of the basin and out the opposite narrow end with overflow weir or weirs only at the other narrow end? Is it not self-evident that there is greater practical weir length per unit of volume with the circular or square basin than with a rectangular basin whose width is usually one-fourth or less of its length? For a single weir at the outlet end of such a rectangular basin there is but one-eighth as much weir length per unit of volume as in a square basin of equal volume. We doubt whether Euclid would attempt to refute that statement.

W. W. AULTMAN
L. R. HOWSON

Chicago, Ill.
Oct. 21, 1955

Being non-Euclidian, non-Aristotelian, and non compos mentis in this controversy, we're remaining strictly neutral.—
Ed.

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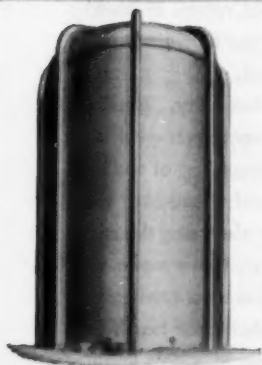
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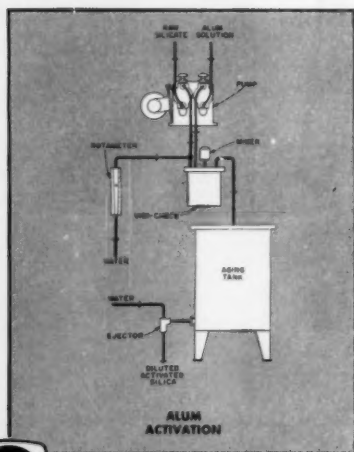
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POLLUTION CONTROL

Pollution of the Mississippi River Near New Orleans. F. W. MACDONALD. *Proc. Am. Soc. of Civil Engrs.*, **80**, Separate No. 552 (Nov. '54). Object of study is to det. degree of poln. of Mississippi R. as it reaches New Orleans, and to det. effect on qual. of water by wastes of city that are discharged into river. Report reviews bact. records from 1934. Correlation of these with variation in stream flow is made. Results are compared with water qual. stds. now in use in various sections to det. suitability of Mississippi R. water as source of raw-water supply for treatment plants and suitability of present stds. as means of evaluating raw-water supply qual. Data is presented to demonstrate that monthly avg. of MPN is poor index of stream poln. One or two extremely high daily figures during month distort avgs. to such extent that they do not give true representation of general conditions for period. Monthly median or geometrical mean is suggested as better index for representing true conditions of period. Sampling practice is also discussed in report. MPN varied with stream flow, greater values occurring generally during min. flows.—*PHEA*

Self-Purification in Estuaries. A. L. H. GAMESON. *Bull. Centre Belge Etude et Document, Eaux (Liege) (Belgium)*, No. 24, p. 71 ('54). In studying poln. and self-purification in estuaries, it is desirable to know overall rate of exchange of oxygen. This can be investigated by 3 methods, all of which are being applied to study of Thames estuary by Water Pollution Research Lab. First method involves detn. of amt. of oxygen entering estuary from various sources. In pold. estuaries, most important means of entry of oxygen is by absorption from atm., and this can be detd. from surface area of estuary, oxygen deficit

(excess of saturation concn. over observed concn.), and exit coefficient (rate of soln. through unit area of surface for unit deficit). Method has been developed for direct measurement of rate of entry of oxygen into water by means of flexible tent containing air, which is placed on water. Avg. rate of entry of oxygen to water over period of several hr can be calc. by detg. initial and final vols. and composition of gas in tent. It has been calcd. that avg. rate of entry of atmospheric oxygen to landward 100 km of Thames estuary is about 1,000,000 kg/day. Estuaries may also receive oxygen already in soln. from sources such as upper river, tributaries, storm water, sewage works effluents of good qual., sea, and rain. For Thames, it has been estimated that amt. of oxygen entering estuary in soln. per day is about 70,000 kg from upper river, 20,000 kg from tributaries, 100,000 kg from sea, 2,000 kg from rain, and slight amts. from sewage and industrial effluents and storm water. Still another source of oxygen in estuary is that produced during photosynthetic activity of phytoplankton, but importance of this in Thames estuary has not yet been investigated. Second method for detg. oxygen balance in estuary is to det. load of org. matter entering estuary from upper river and its tributaries, from sewage and trade waste waters, from storm water and from sea, and to subtract rate at which organic matter is lost from estuary by displacement as result of flow and mixing, by deposition and dredging, and by loss to atm. of gaseous products of anaerobic decomposition. Final method which can be used is to det. rate of oxidation of each element of water of estuary and add rate of uptake of oxygen by mud, but numerous factors have to be taken into consideration in applying this method. By means of these 3 methods, it is hoped to be possible to assess relative importance of various factors which affect oxygenation of Thames estuary and to find explanation of

(Continued on page 64 P&R)

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(Continued from page 62 P&R)

deterioration in its condition during recent years.—PHEA

Streptococci as Indices of Pollution in Well Waters. W. MORRIS & R. H. WEAVER. Appl. Microbiol., 2:282 ('54). MPN of coliform bacteria and streptococci was detd. on 52 wells of various types, dug, drilled or driven, and operated by electric or hand pumps or buckets. All except 2 showed poln. in some degree from very slight to gross. Effect of storage was detd. by collecting duplicate samples, dispatching them on ice, examg. 1 within 6 hr and storing other at room temp. for 24 hr before examg. MPN of coliform bacteria was detd. according to *Standard Methods* with lactose broth at 37°C for presumptive test, BGB at 37°C for confirmatory test, and eosin methylene blue in completed test. MPN of streptococci was detd. by method of Mallmann and Seligmann using Rothe's azide medium at 37°C and confirming by examn. of Gram-stained preparations from sediment for chains of 4

or more cocci. This medium and method permit growth of buccal as well as fecal streptococci. If poln. be judged by nos. of coliform bacteria and streptococci in samples that were examd. immediately, very close agreement in results was shown, nos. of each being roughly equal. Of 46 samples on which comparisons could be made, 23 contained more coliform bacteria than streptococci and 22 more streptococci. Other workers have found much lower nos. of streptococci when limiting test to enterococci. Effect of storage of samples at room temp. for 24 hr was assessed from 37 samples. There was no evidence of multiplication of streptococci in stored samples; in majority of samples, nos. decreased. Change in nos. of coliform bacteria was less predictable; in 12 samples, nos. increased, in several instances by large amts., but in majority of cases, decrease was observed on storage. Most signif. effects of storage were shown when negative results were obtained on stored samples. Negative results for both

(Continued on page 68 P&R)

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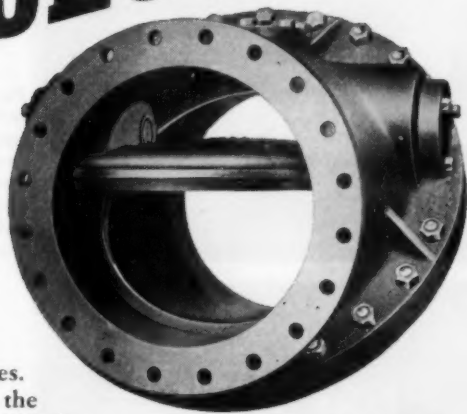
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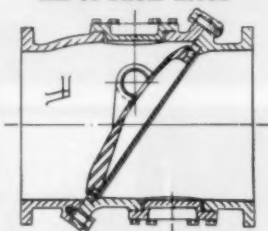
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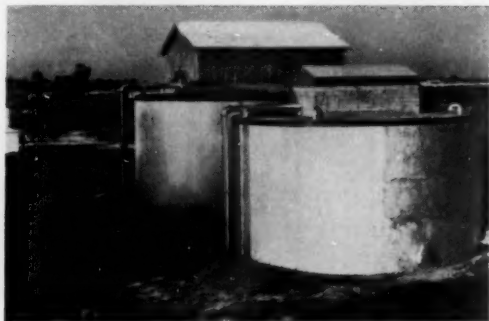
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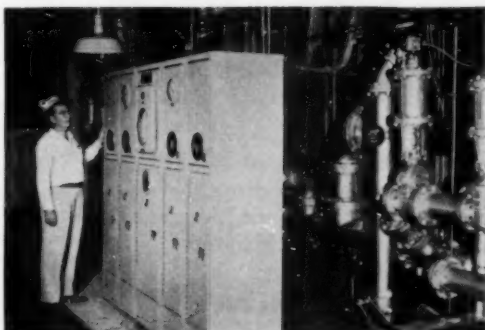
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### Coming Meetings

(Continued from page 8)

**Sep. 17-19**—Kentucky-Tennessee Section, at Hotel Patten, Chattanooga, Tenn. Secretary, J. W. Finney Jr., Howard K. Bell Cons. Engrs., 553 S. Limestone St., Lexington, Ky.

**Sep. 19-21**—Ohio Section, at Commodore Perry Hotel, Toledo. Secretary, M. E. Druley, Dayton Power & Light Co., Wilmington.

**Sep. 26-28**—Wisconsin Section, at Stoddard Hotel, La Crosse. Secretary, L. A. Smith, Supt., Water & Sewerage, City Hall, Madison 3.

### OTHER ORGANIZATIONS

**Feb. 20-23**—American Concrete Institute, at Bellevue Stratford Hotel, Philadelphia.

**Feb. 26-29**—American Institute of Chemical Engineers, Statler Hotel, Los Angeles, Calif.

**Feb. 27-Mar. 2**—American Society for Testing Materials, Hotel Statler, Buffalo, N.Y.

**Mar. 19-20**—Steel Founders Society of America, Drake Hotel, Chicago, Ill.

**Apr. 3-5**—Short Course on Corrosion, at University of Oklahoma Extension Study Center, Norman, Okla.

**Apr. 5-6**—Southern Municipal and Industrial Waste Conference, Chapel Hill, N.C. For information write D. A. Okun, Dept. of Sanitary Engineering, University of North Carolina, Chapel Hill, N.C.

**Jun. 4-8**—American Society of Civil Engineers, Knoxville, Tenn.

**Jun. 17-23**—World Power Conference, Vienna, Austria. US National Committee, World Power Conference, 29 W. 39th St., New York 18, N.Y.

**Oct. 8-11**—Federation of Sewage & Industrial Wastes Assns., Statler Hotel, Los Angeles, Calif.

(Continued from page 64 P&R)

streptococci and coliform bacteria were obtained from 6 samples, although results were positive, and in 3 cases high, from unstored samples. Factor responsible for rapid disappearance of index organisms had similar effects on coliform bacteria and streptococci. On stored samples, therefore, streptococcus test was considered more reliable than coliform bacteria test. If MPN for either organism is arbitrarily chosen at 100 for heavily pold., 10 for lightly pold., and less than 10 for very lightly or unpold. water, both organisms would indicate very close agreement in the classification of samples. It was concluded that coliform bacteria and streptococci had almost equal values as indices of poln. of well waters. Everything else being equal, streptococcus test was preferred, owing to smaller amt. of time and materials required for carrying it out. Though test for fecal streptococci rather than total streptococci might be more specific for intestinal poln., it was considered less satisfactory owing to lower results, so that smaller amts. of poln. would be less readily detected. Most streptococci detected in this survey were of animal origin and indicative of entrance of surface water or water inadequately filtered by soil into wells. Such entrance of surface water was regarded as potentially dangerous whether or not it contained signif. amts. of intestinal poln. at any particular time.—BH

**The Value of Investigation of Phage Activity as a Test of Fecal Contamination of Water. (Demonstration of a Specific Phage for *Salm. typhi*, the Cause of a Recent Waterborne Epidemic.)** P. AMBROSIONI & S. MASONI. *Nuovi Ann. Igiene Microbiol.* (Italy), 5:246 ('54). Explosive outbreak of typhoid fever occurred in rural district near Modena, Italy. The cases were scattered over wide area, but all patients were served by same piped-water supply. Main reservoir, and 1 of 4 springs which fed it, were found to contain large nos. of soil bacteria and others, suggesting fecal contam., but *Salmonella typhi* was not isolated in culture. On assumption that many more phage particles than typhoid bacilli would be present, attempt was made to isolate bacteriophage from water of suspect spring. Strain of phage was successfully obtained, and it proved to be active only against strain of *Salm. typhi* isolated in

(Continued on page 72 P&R)



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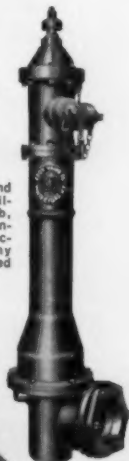
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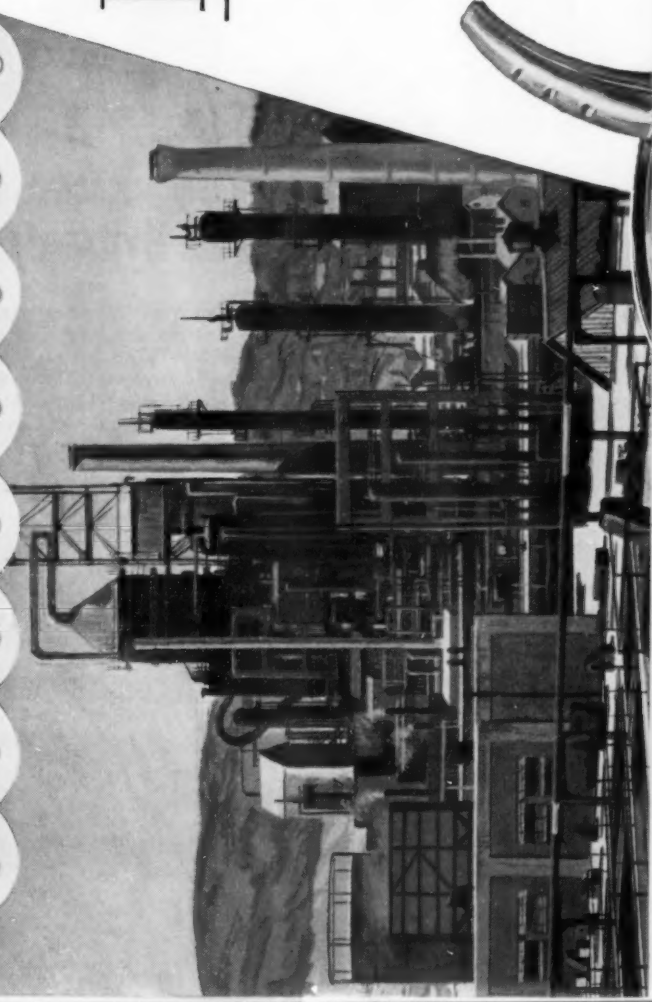
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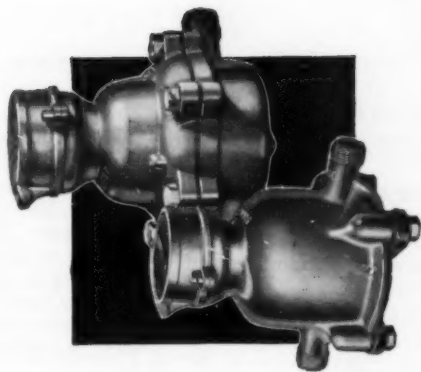
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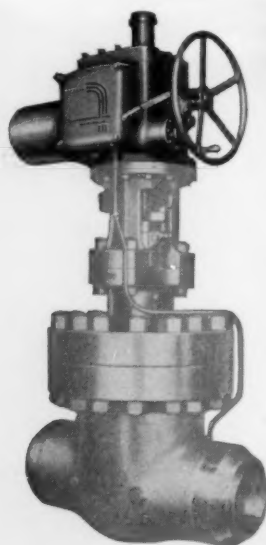
(Continued from page 68 P&amp;R)

blood culture from one of patients, thus confirming origin of epidemic.—BH

**Control of Stream Pollution.** L. A. KAY. Munic. Util. (Can.), 92:10:28 (Oct. '54). Rational approach requires clear-cut policy on reasonable control and max. usage (without abuse) of stream potential. Legislation, other than health act, is required, administered preferably by impartial board or commission and executed jointly by user agency and tech. consultants of control group, possibly with licensing of major pollution agencies and adequate penalties for noncompliance. In case of conflict of interests, governing principle should be greatest benefit for majority, or inversely, min. offense to minority group. Care must be observed that lack of technical staff and facilities does not result in stagnation of program, and complexities of any individual situation must not be allowed to overshadow overall picture. Industry or municipality should be required to submit plan for abatement or

control and to provide necessary technical resources to police proposal, subject only to periodic check by supervising agency, weekly, monthly or quarterly reports being submitted to latter. Thus user required to solve problem created. Merits of stream classification must be considered and idealistic standards may have to be modified, with due regard to public health.—R. E. Thompson

**Pollution Indicators of Surface Waters in Their Correlation to the Coliform Group.** L. BUKOVSKY. Casopis Lékařů Českých (Czech.), 93:1051 ('54). Frequency distributions of data obtained in analyses of 251 samples of river water were plotted on logarithmic scale. Correlation coeffs. between no. of coliform bacteria (I) and 21 further characters were calcd. Highest correlation was found between I and no. of psychrophilic and mesophilic organisms and  $NH_3$  concn.; neg. correlation was found between I and concn. of O and O deficit.—CA



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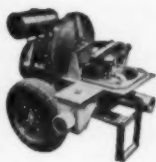
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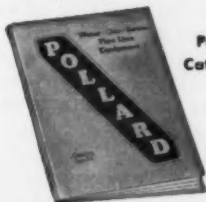
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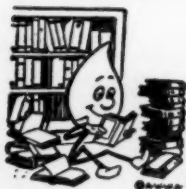
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**Handbook of Graphic Presentation.** Calvin F. Schmid. Ronald Press Co., 15 E. 56 St., New York 10, N.Y. (1954) 318 pp.; \$6

Because of the importance of graphs and charts as a means of presenting, relating, and analyzing data, a study of the principles and techniques associated with these devices is well worth while. This manual clearly sets forth the elements of graphic design, describes the use of drafting tools and equipment, and shows how various types of charts can be adapted to different kinds of data. Anyone concerned with the communication of numerical information, whether to a technical audience or to the general public, will find this a useful book.

**Soil and Water Conservation Engineering.** Richard K. Frevert, Glenn O. Schwab, Talcott W. Edminster & Kenneth K. Barnes. John Wiley & Sons, 440-4th Ave., New York 16, N.Y. (1955) 479 pp.; \$8

Intended as a professional text for agricultural engineering students, this book offers an integrated treatment of various aspects of conservation from the engineering viewpoint. It presents a concise review of hydrology and soil physics, and devotes chapters to erosion and its control, earth dams, flood control, drainage, irrigation, land clearing, terracing, gully control, and legal aspects. The authors stress the importance of sound engineering design for successful conservation, and supply enough field data to illustrate practical applications.

**Review of Current Research and Directory of Member Institutions.** Engineering College Research Council, American Society for Engineering Edu-

cation, New York University, University Heights, New York 53, N.Y. (5th ed., 1955) 352 pp.; paperbound; \$2

This biennially published reference work lists the research projects—and the officers, policies, income, and expenditure connected with them—at 105 leading engineering schools. Also included are the short courses and conferences scheduled at these institutions.

**The Vertical Pump by Johnston.** A. W. Moore & Howard Sens, eds. Johnston Pump Co., 3272 E. Foothill Blvd., Pasadena, Calif. (1954) 392 pp.; \$10

Much information of value to the designer of vertical-pump installations is contained in this Johnston Pump Co. engineering manual. The development of ground water resources, geology, drilling methods, well logging, and design and performance characteristics of vertical turbine, mixed-flow, and propeller pumps are among the topics covered. Basic design principles are outlined and practical examples are given. Tables and graphs of relevant data are appended.

**Note:** The review of the water and sewage works training manuals published by Texas A&M College (November 1955 JOURNAL, p. 50 P&R) listed only the water works manuals. These do not include material on sewage works, as some prospective purchasers were led to believe. Two separate sewage works training manuals (Unit I—Sewage Works Operation; and Unit II—Sewage Works Operation: The Treatment Plant) are available at a price of \$1.00 per unit, including instructor's lesson plans, from: Texas Engineering Extension Service, Texas A&M College, Box 236 F.E., College Station, Tex.

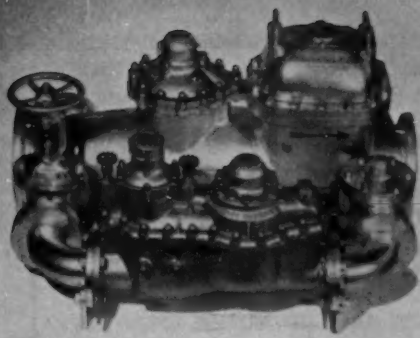
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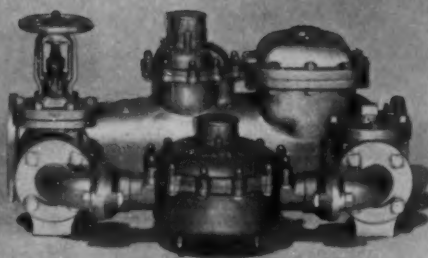
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## Section Meetings

**Alabama-Mississippi Section:** The Alabama-Mississippi Section's eighth annual conference was held at the Buena Vista Hotel, Biloxi, Miss., Oct. 30-Nov. 2, 1955. There was a total registration of 257, including 71 ladies. At the business session on Nov. 2 the following officers were elected for the coming year: chairman—W. U. Quinby, manager of utilities, Jasper, Ala.; vice-chairman—H. L. Burns, manager, Wholesale Supply Co., Jackson, Miss.; secretary-treasurer—I. E. Anderson, district engineer, US

Geological Survey, Jackson; and director—W. H. H. Putnam, manager, Water Works Board, Birmingham.

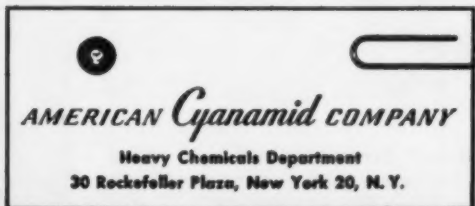
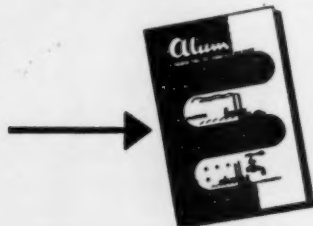
During the course of the meeting, members and wives were given an opportunity to take a cruise to Ship Island, a tour of the harbor and fisheries, and a tour of Biloxi and vicinity. The social events included a "Get Acquainted Hour" on Oct. 30, a "Sea Food Supper and Party" given by the city water department on the following evening, and—on two occasions—a "Club Room" hour through the courtesy of the manufacturers.

(Continued on page 78 P&R)

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1. It feeds uniformly, without trouble, in solid or liquid form.
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Photo shows 675,750 gal. water tank of Waukesha, Wis. Water Utility. Built in 1934, it has needed no maintenance. Architect: M. F. White. Structural engineer: W. S. Hewett.



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33 W. Grand Ave. } A national organization to improve and extend the uses of portland cement  
Chicago 10, Ill. } and concrete through scientific research and engineering field work

**Section Meetings***(Continued from page 76 P&R)*

At the banquet and dance on Nov. 2, it was announced that Charles W. White, who had served the section faithfully for many years as secretary-treasurer, was to receive the Fuller Award. One of the outstanding features of the banquet was the superb singing of the Gulf Park College choral group.

The technical sessions were well planned and presented and were enjoyed by all. A list of the papers and their authors appeared in the December 1955 JOURNAL (p. 1229).

It has been found that a more enjoyable and interesting meeting can be had when the wives of the members attend in large numbers and are well entertained. The record of the meeting would not be complete unless the delightful program for the ladies were mentioned. In addition to the entertainment and social hours described above, the ladies were offered a tour of the Pascagoula Shipyards and a

visit to the Longfellow House, where they enjoyed a delightful luncheon on Monday, Oct. 21. After lunch they toured the Old Spanish Fort and returned to Biloxi. On Tuesday morning a bingo party with prizes and refreshments was given at the hotel. Wednesday the Ladies Program was completed with a luncheon and fashion show.

The entire convention program was judged one of the best ever presented and generated considerable interest. All sessions were well attended.

C. W. WHITE  
Secretary-Treasurer

**Chesapeake Section:** The Chesapeake Section held its annual meeting Oct. 26-28, 1955, Wednesday, Thursday, and Friday, at the Sheraton Park Hotel, in Washington, D.C. At the business meeting on Thursday, Bernard L. Werner, water engineer, Baltimore, was elected chairman

*(Continued on page 80 P&R)*

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Mayor Gets an Estimate of Annual Shortage Owing to Old or Faulty Meters

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Report Calls for Program of Testing Aimed Mainly at 'Slippage' in Devices

New York City is losing \$3,000,000 a year because of defective and outmoded water meters, Mayor Wagner was told yesterday.

Because of faulty and outworn meters, 40,000,000 gallons of water were reported "going down the drain" every day without being registered.

Reprinted from:  
The New York Times  
Tuesday, Nov. 22, 1955

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faulty registration with  
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metering of CALMET...

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FORT WORTH, TEXAS



**Section Meetings***(Continued from page 78 P&R)*

and R. W. Haywood Jr., of du Pont Co., vice-chairman. J. C. Smith, assistant chief, Water Supply Div., Washington, and A. Russell Vollmer, of Baltimore, were elected to 2-year trusteeships. C. J. Lauter was reelected secretary-treasurer.

The entire meeting was well attended, with a registration of 180 members and guests, exclusive of the 32 ladies who registered for their part of the program. Topics at the technical sessions were timely, interesting, and well presented from beginning to end, and attendance was gratifying during the 1½ days of sessions. (A list of papers and authors may be found on p. 1231 of the December 1955 JOURNAL.)

Social activities opened with a "Get Together" Wednesday evening, while on Thursday there was the usual enjoyable "Cocktail Hour," both through the courtesy of the WSWMA, which also assisted

at the banquet Thursday evening. The latter had a splendid attendance of about 200 members, guests, and ladies, who enjoyed the excellent dinner music. A Life Membership was presented to W. D. Collins. Following the formalities, there was dancing in the lovely Continental Ballroom of the Sheraton Park Hotel, during which door prizes were presented.

In addition, the Ladies Committee, headed by Mrs. J. C. Smith and Mrs. David Wood, provided a tour through the National Institutes of Health at Bethesda, Md., on Thursday morning and luncheon at the Kenwood Country Club.

There was also a breakfast on Friday, attended by twelve past-presidents of the Chesapeake Section and its predecessor, the Four States Section.

C. J. LAUTER  
Secretary-Treasurer

*(Continued on page 82 P&R)***For Public Water Fluoridation****Sodium Silicofluoride—98%****(Dense Powder)****Sodium Fluoride—98%****(Dense Powder or Granular)****Meets AWWA specifications****White or tinted blue****Minimum of dust in handling****Minimum of storage space****Available in bags and drums****The AMERICAN AGRICULTURAL CHEMICAL Co.****50 Church Street, New York 7, N. Y.**

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concrete pipe for  
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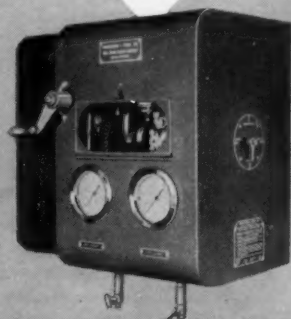
**Section Meetings***(Continued from page 80 P&R)*

**Iowa Section:** The annual meeting of the Iowa Section was held in Des Moines on Oct. 19-21, 1955, at Hotel Fort Des Moines. It was undoubtedly the most successful meeting of the Section since its reorganization in 1945, with a record attendance of 286.

On Wednesday, Oct. 19, G. H. Hershey, director of the Iowa Geological Survey, told about the work of the National Water Resources Policy Board and emphasized the need for a policy in Iowa. Max Suter, of the Illinois Water Survey, described the experiments he had been conducting at Peoria, Ill., in connection with high-rate ground water recharge. His paper contains much information which should be of interest to water works engineers everywhere. R. L. Morris, chief chemist at the Iowa Hygienic Lab. at Iowa City, reviewed all the information he had been able to collect pertaining to radioactive fallout. His

conclusions were that, except in case of war, the water works men in the United States need have no fear of serious effects of fallout. M. K. Tenny, assistant manager of the Des Moines Water Works, described the types of iron bacteria commonly found in Iowa ground water; their effect on turbidity, taste, and odor; and methods of controlling their growth.

M. P. Powell, associate professor of hygiene and preventive medicine at Iowa State University, Iowa City, told of the difficulties experienced in converting water from the Iowa River into a safe, palatable supply for the university. He described the seasonal fluctuations and stated that, in his opinion, the increased amount of fertilizer used by farmers was aggravating bacteriological problems. J. J. Hinman Jr., consulting chemist, Iowa City, showed a series of interesting slides and told of his recent work in Central America. Absence of roads and lack of

*(Continued on page 84 P&R)*

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POPPET TYPE  
MULTIPORT  
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A masterpiece of workmanship and operating simplicity. Your choice of manual, semi-automatic, or fully automatic.

**SERVICE**—Many millions of gallons of water are treated daily by equipment using the H & T poppet valve. Over 1,000 are now in use and the number is rapidly increasing. Many of the original valves are now in use for over 10 years.

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For underground installations, only the *highest* quality should be considered . . . that's why Water Departments all over the country have been using HAYS Water Service Products for over 80 years.

HAYS makes a complete line of Corporation and Curb Stops conforming to all A.W.W.A. Standards.

Have you investigated the advantages of the HAYS DUO-STOP, (a combined Corporation Stop and Saddle) for safe and easy installation on small service lines?

The HAYS Model B Tapping Machine, with aluminum alloy body, is  $\frac{1}{3}$  lighter, easier to carry, easier and faster to operate, gives more working room . . . really designed for "the man in the ditch."

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WATER WORKS PRODUCTS

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## Section Meetings

(Continued from page 82 P&R)

chemicals were the chief problems of most of the communities, but the operators were doing a fairly good job.

On Thursday, Oct. 20, the discussion turned to local problems. C. K. Mathews, of Burns & McDonnell Eng. Co., talked about water works policies for suburban areas. D. Y. Caldwell, superintendent at Newton, told what he thought a water customer had a right to expect from the water works. Mark Driftmier and H. F. Seidel dealt with the effects of air conditioning and what should be done about it. The discussions were timely and aroused a great deal of interest.

The business session was well attended, and the reports of the various committee members were informative and interesting. The Iowa Section can well be proud of the work it is sponsoring, with the cooperation of the state sanitary engineers and the professors at the university.

The following men were elected officers for 1956: chairman—D. L. Bragg; first vice-chairman—P. F. Morgan; second vice-chairman—H. V. Pedersen; and secretary-treasurer—J. J. Hail.

On Friday morning, water works records were discussed by J. W. Straub; meters, by Sidney Peterson; hydrants and valves, by F. L. Wehrle; and elevated-tank maintenance, by Earl Bagenstos. These discussions stimulated many questions from the floor, and the time to adjourn came all too soon.

H. V. PEDERSEN  
Secretary-Treasurer

**Wisconsin Section:** The Wisconsin Section held its 34th annual meeting in Milwaukee at the Hotel Schroeder on Sep. 21-23, 1955. The attendance was 291. The officers elected for the ensuing year are: chairman—Bruno Hartman,

(Continued on page 86 P&R)

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A Harco Cathodic Protection System will pay for itself many times over. It costs nothing to investigate the tremendous savings available to you.

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Los Angeles • Seattle • Houston • Atlanta • Lynchburg • Pittsburgh • Albany • Davenport • Toronto, Canada

**Section Meetings***(Continued from page 84 P&R)*

Sheboygan; vice-chairman—James E. Kerslake, Milwaukee; secretary-treasurer—Leon A. Smith, Madison; assistant secretary—Harry Breimeister, Milwaukee; trustee—Harvey Wirth, Madison; and trustee, ex officio (immediate past-chairman)—Zenno A. Gorder, La Crosse. (The national director, Jerome C. Zufelt, Sheboygan, was elected in 1954.) The Fuller Award Committee selected Henry Ernest Skibbe, of Oshkosh, as the recipient of the 1955 award.

Registration began Wednesday morning, Sep. 21. Preliminaries at the opening session in the afternoon, presided over by Chairman Gorder, included the official greeting by Mayor Frank P. Zeidler, of Milwaukee, who called attention to the fact that the hot, dry weather during the past summer emphasized the value of the public water supply and indicated the necessity of additional facilities in many Wisconsin cities, including Milwaukee.

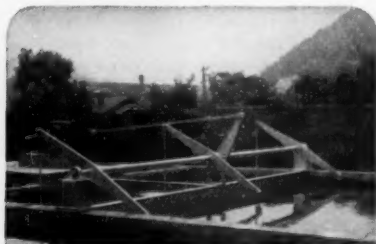
The response was made by Chairman Gorder.

The technical sessions got under way Wednesday afternoon. A list of the papers presented will be found in the December 1955 JOURNAL, p. 1238.

The banquet, held Thursday evening, was presided over by Chairman Gorder. Life Membership Certificates were presented to O. J. Muegge and William U. Gallaher, manager of the Appleton Water Dept., after which there was a floor show.

A very fine women's program was provided, including a tour of the Miller Brewing Co. and a luncheon and card party at Chalet-on-the-Lake. A very successful innovation at this meeting was the coffee hour held each morning from 9 to 11 AM to provide a place for the ladies to meet and become acquainted.

LEON A. SMITH  
Secretary-Treasurer



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(Continued from page 48 P&R)

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**George F. Habach** has been elected vice-president in charge of engineering for Worthington Corp., succeeding Harry A. Feldbush, who continues as consultant on special engineering problems.

**Blair I. Burnson**, executive assistant to the general manager, East Bay Municipal Utility Dist., Oakland, Calif., died Oct. 26, 1955, after brief hospitalization. He was 44. Mr. Burnson began his 21 years of service

with the district as a filter operator in 1934. He was appointed executive assistant in May 1954, having previously been assistant sanitary engineer, sanitary engineer, and supervising sanitary engineer.

Active in water works affairs, he had been an AWWA member since 1935 and was chairman of the Task Group on Biological Infestation of Purified Water. He also belonged to FSIWA and APHA and was the incoming president of the Bay Area chapter of ASCE.

**James R. Cortese**, retired superintendent of the Livingston, Mont., water works, died Oct. 23, 1955, at Los Angeles, after a lengthy illness. He was 65. Born in 1890 in New York City, he was educated at Marquette Univer-

(Continued on page 90 P&R)

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For almost a century Cole elevated tanks have been helping provide uniform water pressure, fire protection and adequate water reserve in scores of American cities.

Capacities 5,000 to 2,000,000 gallons—with hemispherical, ellipsoidal or conical bottoms. Also flat-bottom tanks for stand-pipe storage. Correctly built in accordance with AWWA specifications.

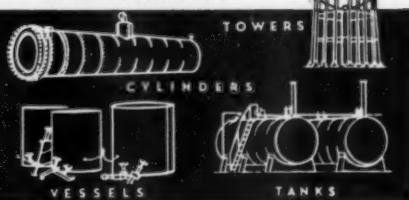
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With the system installed one operator can check, alter and control the treatment process from a master control panel . . . confident of complete dependability . . . minimum maintenance.

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RUST REMOVAL • DEMINERALIZATION • SOFTENERS

**General Filter Company**  
AMES, IOWA

... better water

Ask for recommendations for a water treatment plant "job-engineered" to your requirements . . . a fast, efficient, economical system by General Filter.

(Continued from page 88 P&R)

sity, Milwaukee, Wis. In 1918 he was named water superintendent at Livingston, a post he held until his resignation due to poor health 2 years ago. He was also city engineer for most of this period.

An AWWA member since 1955, he was chairman of the Montana Section in 1931, director in 1945-48, and a recipient of the Fuller Award in 1951.

**Frank Woodbury Jones**, a senior partner in the consulting engineer firm of Havens & Emerson, Cleveland and New York, died Nov. 17, 1955, at his home in Garfield Heights, Ohio. He was 69. Born at Mahone Bay, N.S., in 1886, he became a naturalized American citizen early in life. In 1909 he received a B.S. degree from Worcester (Mass.) Polytechnic Institute, where he taught chemistry until 1911. He served as a sanitary chemist at Worcester and Fitchburg, Mass., until 1918, when he became assistant engineer for the New York State Dept. of Health. The following year he accepted a position as sanitary chemist in charge of tests and operation in the sewage disposal division at Cleveland. He joined the firm of George B. Gascoigne in 1923 and, on the latter's death in 1940, became a partner in the successor firm of Havens & Emerson. Mr. Jones was well known in the field of sanitary engineering and had much to do with the design and operation of numerous large filtration and sewage treatment installations throughout the United States.

An AWWA member since 1923, he also belonged to ASCE (chairman, Sanitary Engineering Div. Executive Committee, 1952), ACS, NEWWA, NSPE, and sewage works associations in New Jersey, Pennsylvania, and Ohio.

**Paul H. Lemon**, superintendent of water and sewer maintenance at Saginaw, Mich., died Oct. 26, 1955. A graduate of what is now Michigan State University, he joined Saginaw's Div. of Engineering in 1927, when the water works was under construction. He continued to work in the division on water design and construction until 1945, the year he was named to the position he held at the time of his death.

Mr. Lemon became an AWWA member in 1947. He was a charter member and the first president of the local chapter of the Michigan Society of Professional Engineers. He was also active in civic work.

**George B. Prindle**, superintendent of the Highland Park, Ill., Water Works, died Jan. 8 of an accidental fall while visiting his daughter's home at Garden City, Long Island, N.Y. He was 74. Born in Maryland, he was trained in patent and engineering law, holding an LL.D. In 1912 he became associated with Shields & Gerber. After service as a first lieutenant in the Engineer Corps, he joined the consulting firm of Pearse, Greeley & Hansen (now Greeley & Hansen), Chicago. Coming to Highland Park as the firm's representative in the construction of a water filtration plant for the city, Mr. Prindle stayed on as water superintendent, a post he filled for 25 years. The plant has been renamed the George B. Prindle Water Works in his memory.

A Life Member of AWWA (joined in 1924), he was chairman of the Illinois Section in 1940. He was also a moving spirit in the West Shore Water Producers Assn., serving as its corresponding secretary for a quarter of a century.



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The long lengths of lightweight steel pipe made handling easier, faster . . . with fewer joints required along the line. Moreover, steel's high beam strength meant fewer supports on spans.

Precision-made and factory-tested, Dresser Couplings, combined with steel pipe, supply "packaged pipe lines", ready for immediate, foolproof installations at site . . . with permanent, bottle-tight joints assured.

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## NEW MEMBERS

Applications received Dec. 1-31, 1955

**Abrahams, John D.**, Supt., Water Production, 316 W. 20th St., Sanford, Fla. (Jan. '56) *MRP*

**Anderson, Herbert E.**, Field Repr., Jacuzzi Brothers Inc., Box 1183, Muskogee, Okla. (Jan. '56) *RD*

**Appelboom, Morris S.**, Chief, Div. of Water Control, Dept. of Health, Bureau of San. Eng., 125 Worth St., New York, N.Y. (Jan. '56) *PD*

**Arellano, Adolfo**, Civ. Engr., Arellano y Batista, Linea corner 10th, Vedado, Havana, Cuba (Jan. '56)

**Bartz, Eliwood Lewis**, Civ. Engr., Board of Water Supply, City & County of Honolulu, Box 3410, Honolulu 1, Hawaii (Jan. '56) *MR*

**Bennett, William C.**; see Penn Instruments Div.

**Biggers, John W.**, Supt. of Purif., Water Dept., 20 E. Salem Ave., Roanoke, Va. (Jan. '56) *P*

**Bond, Albert L.**, Water Meter Repairman, Water Dept., Kennewick, Wash. (Jan. '56) *D*

**Bongiovanni, Joseph J.**, Vice-Pres., M. A. Bongiovanni Inc., 309 Sunset Ave., Syracuse, N.Y. (Jan. '56) *MRPD*

**Brodermann, Jorge**, Civ. Engr., Calle 23 No. 1008, Vedado, Havana, Cuba (Jan. '56)

**Bussells, William P.**, Partner, Harms & Bussells, 8 Crain Hwy., Glen Burnie, Md. (Jan. '56) *MD*

**Caldwell, John C.**, Resident Engr., Piatt & Davis, Drawer 970, Durham, N.C. (Jan. '56) *RP*

**Cheek, Leon C., Jr.**, Design Engr., Wm. C. Olsen & Assoc., Raleigh, N.C. (Jan. '56) *MRPD*

**Coughlin, David J.**, Asst. Product Mgr., Fibre Products, Line Material Co., 700 W. Michigan Ave., Milwaukee, Wis. (Jan. '56) *PD*

**Dixon, Carl**, Vice-Pres., Harry Dixon & Sons Inc., 250 Park Ave., New York 17, N.Y. (Jan. '56)

**Duensing, Robert W.**, Mgr., Water & Waste Treatment Div., Bailey Meter Co., 53 W. Jackson Blvd., Chicago 4, Ill. (Jan. '56) *MPD*

**Erdel, Joseph F.**, Chemist, Metropolitan Utilities Dist., 18th & Harney Sts., Omaha, Neb. (Jan. '56) *P*

**Eye, John D.**, Assoc. Professor, San. Eng., Virginia Polytechnic Inst., Blacksburg, Va. (Jan. '56)

**Ferguson, J. Carl**, Supt., Water Works, Winder, Ga. (Jan. '56) *PD*

**Finch, A. E.**; see Quartz Hill County (Calif.) Water Dist.

**Harms, John E., Jr.**, Partner, Harms & Bussells, 8 Crain Hwy., Glen Burnie, Md. (Jan. '56) *RP*

**Harris, James L.**, Mfr.'s Repr., Southwire Co., 619 Yaddin St., Albemarle, N.C. (Jan. '56) *D*

**Hilbrant, Roy O.**, Water Distr. Supervisor, Water Dept., 827 E. Jefferson St., Phoenix, Ariz. (Jan. '56) *D*

**Hinds County Water Co.**, Edward A. May, Supt., Box 8127, Battlefield Sta., Jackson, Miss. (Corp. M. Jan. '56) *MRD*

**Irwin, Joseph B.**, Supt., Water & Sewerage Dept., Utilities Board, Maryville, Tenn. (Jan. '56) *M*

**Johnson, John O.**, Civ. Engr., Pope & Talbot Inc., 208 Walker Bldg., Seattle 1, Wash. (Jan. '56) *RD*

**Kahn, Samuel C.**, Asst. Supt., Tech. Sec., Belle Works, E. I. du Pont de Nemours & Co., Inc., Belle, W.Va. (Jan. '56) *RPD*

**Kay, George W.**, Civ. Engr., James M. Montgomery, 15 N. Oakland Ave., Pasadena, Calif. (Jan. '56) *MRPD*

**Kean, Robert W., Jr.**, Pres., Elizabethtown Water Co., 22 W. Jersey St., Elizabeth, N.J. (Jan. '56) *MR*

**Kerkhoff, Harold E.**, Service Engr., B-I-F Industries, Inc., c/o Purser & London, Inc., Charlotte, N.C. (Jan. '56)

**King, E. R.**, Supt., Water Plant, City Hall, Goldsboro, N. C. (Jan. '56) *MP*

**Leete, J. F.**, Sales Repr., Kellam Foundry, High Point, N.C. (Jan. '56)

**Leibfarth, Albert G.**, Mgr., Charlotte Branch, John Wiley Jones Co., 610 McNinch St., Charlotte, N. C. (Jan. '56) *MRPD*

**Matusky, Felix E.**, San. Engr., Lee T. Purcell, 36 DeGrasse St., Paterson, N.J. (Jan. '56) *PD*

**May, Edward A.**; see Hinds County (Miss.) Water Co.

**McCart, Claude Arnold**, Outside Gen. Foreman, Wichita Water Co., 301 N. Main, Wichita, Kan. (Jan. '56) *D*

**McDougall, William H.**, Pres.-Gen. Mgr., Magnolia Constr. Co., Inc., Audobon Sta. Box 4628, Baton Rouge, La. (Jan. '56) *D*

**Miller, Irvin E.**, Lab. Supt., Standard Oil Co., Mandan, N.D. (Jan. '56)

**Penn Instruments Div.**, Burgess-Manning Co., William C. Bennett, Mgr., 4110 Haverford Ave., Philadelphia 4, Pa. (Assoc. M. Jan. '56)

**Presecan, Nicholas E.**, Gen. Mgr., Twenty-nine Palms County Water Dist., Box 1500, Twenty-nine Palms, Calif. (Jan. '56) *MRPD*

**Preul, Herbert C.**, San. Engr., Omaha Dist. Corps Engrs., 16th & Douglas Sts., Omaha 1, Neb. (Jan. '56) *P*

**Quartz Hill County Water Dist.**, A. E. Finch, Secy.-Mgr., 42141 N. 50th St., W., Quartz Hill, Calif. (Corp. M. Jan. '56) *MD*

**Read, Willett W.**, Asst. Engr., W. E. Matthews Co., Laurinburg, N.C. (Jan. '56) *PD*

**Reld, Hubert**, Supt., Water Dept., Leachville, Ark. (Jan. '56) *MP*

**Rennie, Robert P.**, Chief Chemist, Canadian National Railways, 1801 Le Ber St., Montreal, Que. (Jan. '56) *RP*

**Ringstrom, Robert M.**, Assoc. Engr., Water Dept., 3854 Mulberry St., Riverside, Calif. (Jan. '56) *R*

**Roe, William Ernest**, Director of Public Works, City Hall, Paso Robles, Calif. (Jan. '56) *M*

**Ross, Boyd J.**, Salesman, National Tube Div., US Steel Corp., 1132 Greenwood Cliff, Charlotte, N.C. (Jan. '56)

**Ross, F. Kelly**, Salesman, Diamond Alkali Co., Box 667, Raleigh, N.C. (Jan. '56)

**Saito, Genryo**, Director & Chief Engr., Kurimoto Iron Works, Ltd., Kagaya Kojo, 1, 1-chome, Kitajimacho, Sumiyoshiku, Osaka, Japan (Jan. '56)

**Schomaker, William P.**, Dist. Sales Mgr., The Permutit Co., 831 E. Morehead St., Charlotte, N.C. (Jan. '56) *P*

**Schonhardt, John W.**, Supt., Water & Sewers, City Hall, Marshall, Tex. (Jan. '56)

**Sell, Louis, Jr.**, Secy.-Treas., Magnolia Constr. Co., Inc., Audobon Sta. Box 4628, Baton Rouge, La. (Jan. '56) *D*

**Slaughter, Arthur E.**, Geologist, Geological Survey Div., Dept. of Conservation, Escanaba, Mich. (Jan. '56) *R*

**Soule, Ralph M.**, Assoc. San. Engr., State Dept. of Public Health, 511 State House, Boston, Mass. (Jan. '56) *RP*

**Spoerry, Jack T.**, San. Engr., Hq. Alaskan Air Command, Anchorage, Alaska (Jan. '56) *MPD*

**Stead, Ivan W.**, Dist. Sales Mgr., Sparling Meter Co., Inc., 1932-1st Ave., Seattle, Wash. (Jan. '56) *RP*

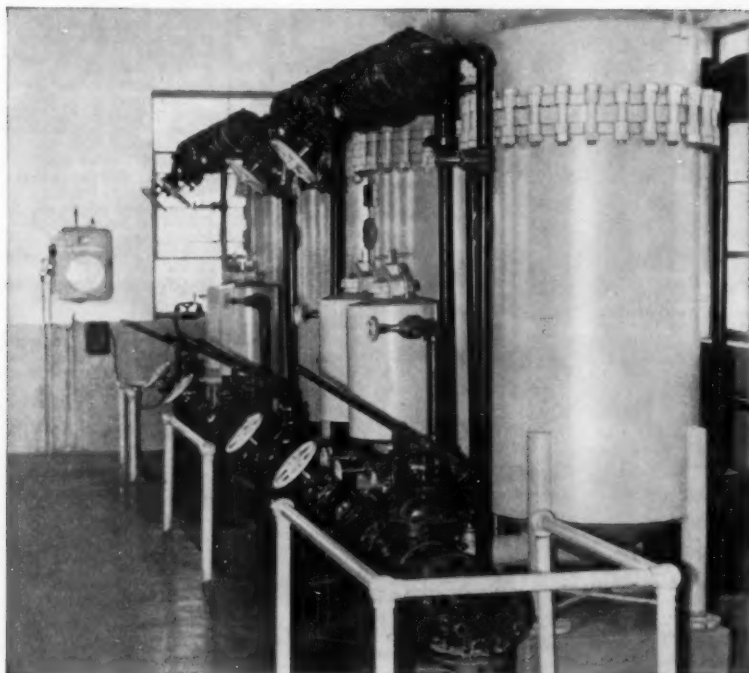
**Thompson, J. F.**, Director, Public Utilities, City Hall, Graham, N.C. (Jan. '56) *MPD*

**Tinsley, Phil B.**, Sales Repr., US Pipe & Foundry Co., 681 Market St., San Francisco, Calif. (Jan. '56) *D*

**Tosar, Jose A.**, Operator, Chlorine Plant, Water Works, Santa Lurgada No. 18-B, Cerro, Havana, Cuba (Jan. '56) *P*

**Winey, Calvin, Jr.**, Regional San. Engr., Alaska Dept. of Health, 327 Eagle, Anchorage, Alaska (Jan. '56) *PD*

**Young, Gus Edwin**, Supt., Water Works Distr., Water Dept., 210 S. Garrett St., San Angelo, Tex. (Jan. '56) *M*

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for America's Paper and Water Industries!

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A 25th plant is being added to General Chemical's coast-to-coast network of aluminum sulfate production centers! The new liquid alum plant at Hopewell, Va. will serve paper mills and water and sewage treatment plants in the area . . . just as General's other facilities provide for needs of consumers near them.

### Expansion That Assures Continued Good Service and Dependable Supplies

General Chemical dry and liquid aluminum sulfate has long been the first choice of industrial and municipal users everywhere. They have found

they can always count on General Chemical for the right grades made to their requirements, with the same uniform high quality lot after lot.

**Equally important**--they know that General's policy of building its plants at locations convenient to consuming centers means fast service and a reliable near-by source of supply they can depend upon in emergencies and at all times.



Basic Chemicals  
For American Industry

Acids  
Alums  
Fluorine  
Compounds

Phosphates  
Sodium Compounds  
Other Industrial  
Chemicals

## GENERAL CHEMICAL DIVISION

ALLIED CHEMICAL & DYE CORPORATION

40 Rector Street, New York 6, N. Y.

Offices in Principal Cities

In Canada: The Nichols Chemical Company, Limited • Montreal • Toronto • Vancouver

**Softening Chemicals and Com-****pounds:**

Calgon, Inc.  
Cochrane Corp.  
General Filter Co.  
Inflico Inc.  
Morton Salt Co.  
Permutit Co.  
Tennessee Corp.

**Standpipes, Steel:**

Chicago Bridge & Iron Co.  
R. D. Cole Mfg. Co.  
Graver Water Conditioning Co.  
Hammond Iron Works  
Pittsburgh-Des Moines Steel Co.

**Steel Plate Construction:**

Bethlehem Steel Co.  
Chicago Bridge & Iron Co.  
R. D. Cole Mfg. Co.  
Graver Water Conditioning Co.  
Hammond Iron Works  
Pittsburgh-Des Moines Steel Co.

**Stops, Curb and Corporation:**

Hays Mfg. Co.  
Mueller Co.

**Storage Tanks; see Tanks****Strainers, Suction:**

James B. Clow & Sons  
M. Greenberg's Sons  
Johnson, Edward E., Inc.  
R. D. Wood Co.

**Surface Wash Equipment:**

Cochrane Corp.  
Permutit Co.

**Swimming Pool Sterilization:**

Builders-Providence, Inc. (Div.,  
B-I-F Industries)  
Fischer & Porter Co.  
Omega Machine Co. (Div., B-I-F  
Industries)  
Proportioners, Inc. (Div., B-I-F  
Industries)

**Wallace & Tiernan Inc.****Tanks, Steel:**

Bethlehem Steel Co.  
Chicago Bridge & Iron Co.  
R. D. Cole Mfg. Co.  
Graver Water Conditioning Co.  
Hammond Iron Works  
Pittsburgh-Des Moines Steel Co.

**Tapping-Drilling Machines:**

Hays Mfg. Co.  
Mueller Co.

A. P. Smith Mfg. Co.

**Tapping Machines, Corp.:**

Hays Mfg. Co.  
Mueller Co.

**Taste and Odor Removal:**

Builders-Providence, Inc. (Div.,  
B-I-F Industries)

Cochrane Corp.

Fischer & Porter Co.

General Filter Co.

Graver Water Conditioning Co.

Industrial Chemical Sales Div.

Inflico Inc.

Permutit Co.

Proportioners, Inc. (Div., B-I-F  
Industries)

Wallace & Tiernan Inc.

**Tenoning Tools**

Spring Load Mfg. Corp.

**Turbidimetric Apparatus (For**

**Turbidity and Sulfate De-**  
**terminations):**

Wallace & Tiernan Inc.

**Turbines, Steam:**

DeLaval Steam Turbine Co.

**Turbines, Water:**

DeLaval Steam Turbine Co.

**Valve Boxes:**

James B. Clow & Sons  
Ford Meter Box Co.  
M & H Valve & Fittings Co.  
Mueller Co.  
Rensselaer Valve Co.  
A. P. Smith Mfg. Co.  
Trinity Valley Iron & Steel Co.  
R. D. Wood Co.

**Valve-Inserting Machines:**

Mueller Co.  
A. P. Smith Mfg. Co.

**Valves, Air/Altitude:**

Golden-Anderson Valve Specialty Co.  
Ross Valve Mfg. Co., Inc.  
S. Morgan Smith Co.

**Valves, Butterfly, Check, Flap,****Foot, Hose, Mud and Plug:**

Builders-Providence, Inc. (Div.,  
B-I-F Industries)

Chapman Valve Mfg. Co.

James B. Clow & Sons

DeZurik Shower Co.

M. Greenberg's Sons

Kennedy Valve Mfg. Co.

M & H Valve & Fittings Co.

Mueller Co.

Henry Pratt Co.

Rensselaer Valve Co.

S. Morgan Smith Co.

R. D. Wood Co.

**Valves, Detector Check:**

Hersey Mfg. Co.

**Valves, Electrically Operated:**

Builders-Providence, Inc. (Div.,  
B-I-F Industries)

Chapman Valve Mfg. Co.

James B. Clow & Sons

Crane Co.

Darling Valve & Mfg. Co.

Golden-Anderson Valve Specialty Co.

Kennedy Valve Mfg. Co.

M & H Valve & Fittings Co.

Mueller Co.

Philadelphia Gear Works, Inc.

Henry Pratt Co.

Rensselaer Valve Co.

A. P. Smith Mfg. Co.

S. Morgan Smith Co.

**Valves, Float:**

James B. Clow & Sons

Golden-Anderson Valve Specialty Co.

Henry Pratt Co.

Ross Valve Mfg. Co., Inc.

**Valves, Gate:**

Chapman Valve Mfg. Co.

James B. Clow & Sons

Crane Co.

Darling Valve & Mfg. Co.

Dresser Mfg. Div.

Kennedy Valve Mfg. Co.

Ludlow Valve Mfg. Co., Inc.

M & H Valve & Fittings Co.

Mueller Co.

Rensselaer Valve Co.

A. P. Smith Mfg. Co.

R. D. Wood Co.

**Valves, Hydraulically Oper-**

**ated:**  
Builders-Providence, Inc. (Div.,  
B-I-F Industries)

Chapman Valve Mfg. Co.

James B. Clow & Sons

Crane Co.

Darling Valve & Mfg. Co.

DeZurik Shower Co.

Golden-Anderson Valve Specialty Co.

Kennedy Valve Mfg. Co.

F. B. Leopold Co.

M & H Valve & Fittings Co.

Mueller Co.

Philadelphia Gear Works, Inc.

**Henry Pratt Co.**

Rensselaer Valve Co.

A. P. Smith Mfg. Co.

S. Morgan Smith Co.

R. D. Wood Co.

**Valves, Large Diameter:**

Chapman Valve Mfg. Co.

James B. Clow & Sons

Crane Co.

Darling Valve & Mfg. Co.

Golden-Anderson Valve Specialty Co.

Kennedy Valve Mfg. Co.

Ludlow Valve Mfg. Co., Inc.

M & H Valve & Fittings Co.

Mueller Co.

Henry Pratt Co.

Rensselaer Valve Co.

A. P. Smith Mfg. Co.

S. Morgan Smith Co.

R. D. Wood Co.

**Valves, Regulating:**

DeZurik Shower Co.

Foster Eng. Co.

Golden-Anderson Valve Specialty Co.

Mueller Co.

Henry Pratt Co.

Ross Valve Mfg. Co.

S. Morgan Smith Co.

**Valves, Swing Check:**

Chapman Valve Mfg. Co.

James B. Clow & Sons

Crane Co.

Darling Valve & Mfg. Co.

Golden-Anderson Valve Specialty Co.

M. Greenberg's Sons

M & H Valve & Fittings Co.

Mueller Co.

Rensselaer Valve Co.

A. P. Smith Mfg. Co.

R. D. Wood Co.

**Venturi Tubes**

Builders-Providence, Inc. (Div.,  
B-I-F Industries)

Inflico Inc.

Penn Industrial Instrument Div.

Simplex Valve & Meter Co.

**Waterproofing**

Intertol Co., Inc.

**Water Softening Plants; see****Softeners****Water Supply Contractors:**

Layne & Bowler, Inc.

**Water Testing Apparatus:**

Wallace & Tiernan Inc.

**Water Treatment Plants:**

Allis-Chalmers Mfg. Co.

American Well Works

Chain Belt Co.

Chicago Bridge & Iron Co.

Cochrane Corp.

Dorr-Oliver Inc.

Fischer & Porter Co.

General Filter Co.

Graver Water Conditioning Co.

Hammond Iron Works

Hungerford & Terry, Inc.

Inflico Inc.

Permutit Co.

Pittsburgh-Des Moines Steel Co.

Roberts Filter Mfg. Co.

Walker Process Equipment, Inc.

Wallace & Tiernan Inc.

**Well Drilling Contractors:**

Layne & Bowler, Inc.

**Well Screens**

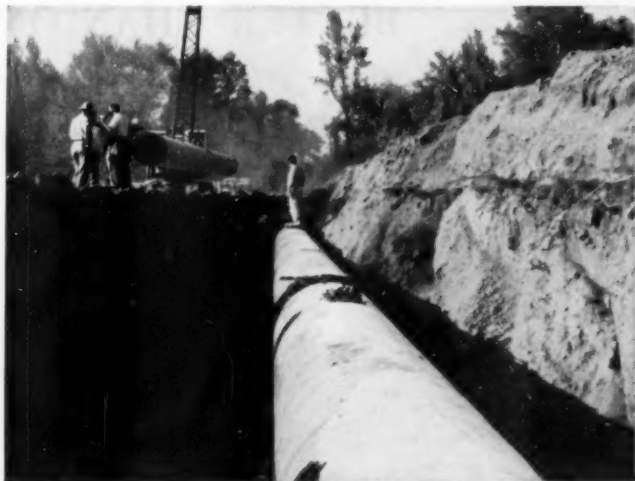
Johnson, Edward E., Inc.

**Wrenches, Ratchet:**

Dresser Mfg. Div.

**Zeolite; see Ion Exchange****Materials**

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1955 AWWA Directory.



## CHOOSE ARMCO STEEL PIPE for trouble-free water lines

You can feel secure when you use Armco Welded Steel Pipe for water supply lines because Armco Pipe eliminates trouble spots. Strong, yet flexible steel pipe withstands high external loads and shifting foundations without cracking. It provides a high safety factor for internal pressure.

To guard against leakage you can get "bottle-tight" mechanical joints or field welds. And linings and coatings can be supplied to A.W.W.A. specifications.

Diameters range from 6 to 36 inches and wall thicknesses from  $\frac{3}{4}$  to  $\frac{1}{2}$  inch.

Armco Drainage & Metal Products, Inc., Welded Pipe Sales Division, 3616 Curtis Street, Middletown, Ohio. Subsidiary of Armco Steel Corporation. In Canada: write Guelph, Ontario.

**WHEREVER WATER FLOWS, STEEL PIPES IT BEST**

### ARMCO WELDED STEEL PIPE

meets A.W.W.A. specifications



## TWO HEADS ARE BETTER THAN ONE!



This assembly consists of two 4-in Rockwell single register compound meters, four Fig. 143 Nordstrom valves and two 8-in reducing manifolds. The over-all laying length conforms to A.W.W.A. standards for 8-in compound meters

### Dual Unit Compound Meter Manifold Is Easiest To Install and Service

An 8-in compound meter is a heavy, bulky piece of machinery. Installation is always a major problem and service a headache. You'll save time and effort—earn greater revenue by using two-meter Rockwell manifold assemblies. *They measure all the flows* with greater accuracy than a single big compound. And the complete assembly weighs approximately 100 lb less. It only takes *two* men to install.

Too, maintenance is simplified since either meter can be used to record off-peak loads while a new or repaired meter is being installed. The cost for all this accuracy and convenience is usually less than for a single big meter. Write for complete details.

#### ROCKWELL MANUFACTURING COMPANY

PITTSBURGH 8, PA. Atlanta Boston Charlotte Chicago Dallas Denver Houston  
Los Angeles Midland, Tex. New Orleans New York N. Kansas City Philadelphia  
Pittsburgh San Francisco Seattle Shreveport Tulsa

In Canada: Rockwell Manufacturing Company of Canada, Ltd., Toronto, Ontario



### ROCKWELL WATER METERS

**in water treatment problems...**

*you won't find identical twins*



No two water treatment problems are exactly alike. The right solution to each can only be arrived at after a careful study of the local conditions. Variables such as raw water composition, rate of flow and results required automatically rule out the cure-all approach. The installation shown below is a good example of how equipment should be selected to fit the job . . . and not vice versa.



*Washington,  
Penna.*

**Filtration Plant  
Construction Costs Cut  
using DORRCO Aldrich  
PeriFilter\* System**

The Citizen's Water Company of Washington, Pennsylvania recently started up this compact, attractive filtration and softening plant. A Dorrcoc Aldrich PeriFilter System was selected as the most economical answer to meet local conditions. Consisting of two 49'6" dia. Dorrcoc Hydro-Treaters, each surrounded by an annular rapid sand filter, the plant has a softening capacity of 4 MGD.

The unique PeriFilter design cuts construction costs because both pre-treatment unit and filter are installed in the same tank. Valves and piping are greatly simplified. Reduced head losses and simple operation add up to lower operating costs.

If you'd like more information on the PeriFilter System write for Bulletin No. 9042. No obligation, of course.



Every day, nearly 8 billion gallons of water are treated with Dorr-Oliver equipment

**DORR-OLIVER**  
INCORPORATED  
WORLD-WIDE RESEARCH • ENGINEERING • EQUIPMENT  
STAMFORD • CONNECTICUT • U.S.A.

\*Trademark of Dorr-Oliver Incorporated

# LEADITE

Trade Mark Registered U. S. Pat. Office

## Jointed for . . . Permanence with LEADITE

Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains **MUST BE GOOD,—MUST BE DEPENDABLE,—**and that is just why so many Engineers, Water Works Men and Contractors aim to **PLAY ABSOLUTELY SAFE,** by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

*The pioneer self-caulking material for c. i. pipe.  
Tested and used for over 40 years.  
Saves at least 75%*



**THE LEADITE COMPANY**  
Girard Trust Co. Bldg. Philadelphia, Pa.

## No Caulking

